Exhibit 4

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Exhibit N

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Deterrence in the Twenty-First Century

ABSTRACT

The evidence in support of the deterrent effect of the certainty of punishment is far more consistent than that for the severity of punishment. However, the evidence in support of certainty's effect pertains almost exclusively to apprehension probability. Consequently, the more precise statement is that certainty of apprehension, not the severity of the ensuing legal consequence, is the more effective deterrent. This conclusion has important policy implications among which are that lengthy prison sentences and mandatory minimum sentencing cannot be justified on deterrence. There are four major research gaps. The first concerns the mechanism by which police affect perceptions of the probability of apprehension. The second concerns the inextricable link between the deterrent effect of the threat of punishment and the potentially criminogenic effect of the experience of punishment. The third concerns the concept of a sanction regime defined by the sanctions legally available and how that legal authority is administered. Theories of deterrence conceive of sanctions in the singular, not the plural, and do not provide a conceptual basis for considering the differential deterrent effects of different components of the sanction regime. The fourth involves sanction risk perceptions. Establishing the link between risk perceptions and sanction regimes is imperative; unless perceptions adjust, however crudely, to changes in the sanction regime, desired deterrent effects will not be achieved.

Three enduring questions have occupied centuries of scholarship on crime and punishment. Does punishment prevent crime? How does punishment prevent crime? And should punishment be used to prevent crime? This essay is concerned with the first two of these questions.

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0192-3234/2013/4201-0004$10.00

The criminal justice system dispenses justice by apprehending, prosecuting, and punishing individuals who break the law. These activities may prevent crime by three distinct mechanisms: incapacitation, specific deterrence, and general deterrence. Convicted offenders are sometimes punished with imprisonment. Incapacitation concerns crimes averted by their physical isolation during the period of their incarceration. Specific and general deterrence involve possible behavioral responses. General deterrence refers to the crime prevention effects of the threat of punishment. Specific deterrence concerns the aftermath of the failure of general deterrence—the effect on reoffending, if any, that results from the experience of actually being punished.

In this essay, I consider the theoretical and evidentiary basis for general deterrence. In another recent *Crime and Justice* essay (Nagin, Cullen, and Jonson 2009), I surveyed the evidence on the specific deterrence effects of imprisonment. Here, I draw heavily from recent and prior deterrence reviews by me and others.

My aim is to provide a succinct summary of the current state of theoretical and empirical knowledge about deterrence in support of several interrelated objectives. The first is to provide a selective intellectual history of deterrence research that identifies important recurring themes. I highlight both what has been learned and persistent flaws that should be addressed in future research.

The second objective concerns the framing of discourse on deterrence, which often takes the same pattern, particularly in policy discussions: one group arguing that sanction threats always deter and another group arguing that sanction threats never deter. When deterrence effects are unpacked, it is clear that sanction threats are not universally efficacious: magnitudes of deterrent effects range from none to seemingly very large. Thus, another primary objective is to move discourse about deterrence away from the equally indefensible positions that deterrence effects are always or never present to a more nuanced and useful inquiry into the basis for variation in the existence and size of deterrent effects.

The third objective is policy related. Prison populations have been rising in the United States for four decades. Only recently have there been signs that the increase is abating. In 2009 and 2010, state-level prison population declined but federal-level population continued to increase (Bureau of Justice Statistice 2012). Less well recognized is that prison populations have risen elsewhere in the world, for example, in

the Netherlands since 1975 and more recently in England and Wales, Portugal, Spain, and New Zealand. An incarceration-based sanction policy that reduces crime solely by incapacitation will necessarily increase the rate of imprisonment. In contrast, if the crime control policy also prevents crime by deterrence, it may be possible to reduce both imprisonment and crime; successful prevention by any mechanism, whether by deterrence or otherwise, has the virtue of averting not only crime but also the punishment of perpetrators. Hence, it is important to identify policies that increase imprisonment but have only negligible effects on crime rates.

My main conclusions are as follows: First, there is little evidence that increases in the length of already long prison sentences yield general deterrent effects that are sufficiently large to justify their social and economic costs. Such severity-based deterrence measures include "three strikes, you're out," life without the possibility of parole, and other laws that mandate lengthy prison sentences.

Second, on the basis of the earlier noted *Crime and Justice* review (Nagin, Cullen, and Jonson 2009), I have concluded that there is little evidence of a specific deterrent effect arising from the experience of imprisonment compared with the experience of noncustodial sanctions such as probation. Instead, the evidence suggests that that reoffending is either unaffected or increased.

Third, there is substantial evidence that increasing the visibility of the police by hiring more officers and allocating existing officers in ways that materially heighten the perceived risk of apprehension can deter crimes. This evidence is consistent with the perceptual deterrence literature that surveys individuals on sanction risk perceptions and relates these perceptions to their actual or intended offending behavior. This literature finds that perceived certainty of punishment is associated with reduced self-reported or intended offending.

Thus, I conclude, as have many prior reviews of deterrence research, that evidence in support of the deterrent effect of various measures of the certainty of punishment is far more convincing and consistent than for the severity of punishment. However, the certainty of punishment is conceptually and mathematically the product of a series of conditional probabilities: the probability of apprehension given commission of a crime, the probability of prosecution given apprehension, the probability of conviction given prosecution, and the probability of sanction given conviction. The evidence in support of certainty's de-

terrent effect pertains almost exclusively to apprehension probability. Consequently, the conclusion that certainty, not severity, is the more effective deterrent is more precisely stated as *certainty of apprehension* and not the severity of the legal consequence ensuing from apprehension is the more effective deterrent. This more precise statement has important policy implications; the empirical evidence from the policing and perceptual deterrence literature is silent on the deterrent effectiveness of policies that mandate incarceration after apprehension. These include policies such as mandatory minimum sentencing laws or sentencing guidelines that mandate incarceration. Thus, this revised conclusion about the deterrent effect of punishment certainty should not be construed as implying that policies mandating severe legal consequences have been demonstrated to achieve deterrent effects.

Together these conclusions have a range of policy implications, particularly as they relate to the United States (Durlauf and Nagin 2011*b*). First, it is clear that lengthy prison sentences cannot be justified on a deterrence-based, crime prevention basis. Thus, the case for crime prevention benefits of measures requiring lengthy prison sentences such as California's three-strikes law must rest on incapacitation. Another implication is that crime prevention would be enhanced by shifting resources from imprisonment to policing or, in periods of declining criminal justice system budgets, that policing should get a larger share of a smaller overall budget.

While accumulation of knowledge about deterrence in the past four decades has been impressive, much remains to be learned. There are four major theoretical and related empirical gaps. The first concerns the deterrent effect of the certainty of apprehension. There are two distinct mechanisms by which the police may deter crime. One stems from their effectiveness in apprehending perpetrators of crimes; by definition this activity involves occurrences in which deterrence has failed. Thus, police effectiveness in successfully apprehending criminal perpetrators can have a deterrent effect only on others or on the perpetrator's future behavior. The second mechanism involves the effect of the intensity of police presence in creating a perception that apprehension risk is sufficiently high that no crime is committed in the first place. I speculate that this second mechanism is the primary source of police effectiveness in deterring crime whereas the first role primarily prevents crime by capturing and incapacitating crime-prone individuals. The research gap involves developing rigorous empirical tests of

this contention and developing improved theoretical models of how police presence and tactics can reduce the attractiveness of criminal opportunities by increasing the perceived risk of apprehension.

The second gap concerns the distinction between specific and general deterrence. The two are inextricably linked because the experience of punishment is a consequence of the failure of the threat of punishment to deter crime, yet no theory of deterrence explicitly addresses how the experience of punishment influences the deterrent effect of the threat of punishment. Relevant issues include how the experience of punishment affects the proclivity to commit crime due to potential stigma effects, sustained contacts with criminals in a prison setting, or participation in rehabilitative programs as well as the effect of the experience of punishment on perceptions of the certainty and severity of sanctions. Analysis of these and other related issues will require longitudinal data on individuals who do and do not have the experience of punishment.

The third theoretical gap concerns the concept of a sanction regime. A sanction regime defines the sanctions that are legally available for the punishment of various types of crime and how that legal authority is administered. Depending on the crime and characteristics of the offenders, such as age or prior record, available sanctions range in severity from verbal reprimands to fines and different forms of community service to lengthy terms of imprisonment and execution. How the legal authority is administered determines the relative frequency with which the available sanction options are used and also the swiftness of their application. Thus, both dimensions of the sanction regime—the legal authority for different types of sanctions and how that authority is administered—combine to determine the certainty, severity, and celerity of sanctioning options available for punishment of a specific type of crime.

Theories of deterrence, however, specify sanction threats in the singular, not the plural. For example, a sizable number of studies examine the question whether capital punishment deters murder. Yet properly understood, the relevant question is the differential or marginal deterrent effect of execution over the deterrent effect of other available or commonly used penalties. In this case the alternative penalty would be a lengthy prison sentence—sometimes life without the possibility of parole. Yet none of the capital punishment studies take account of differences across states and over time in the severity of noncapital pun-

ishments for murder (Nagin and Pepper 2012). Theories of deterrence that conceive of sanctions in the singular do not provide a conceptual basis for considering the differential deterrent effect of different types of sanction options. The empirical companion to this theoretical expansion involves assembling the data required to measure sanction regimes. At least in the United States, such data are largely unavailable.

The fourth theoretical and empirical gap involves sanction risk perceptions, an issue that I emphasized in an earlier review of the deterrence literature (Nagin 1998). Deterrence is the behavioral response to the perception of sanction threats. Establishing the link between risk perceptions and sanction regimes is imperative; the conclusion that crime decisions are affected by sanction risk perceptions is not sufficient to conclude that policy can deter crime. Policy cannot directly manipulate perceptions. It can affect only the variety and severity of sanctions legally available in the sanction regime and the manner of their administration. Unless perceptions adjust, however crudely, to changes in the sanction regime, the desired deterrent effect will not be achieved.

Since the publication of Nagin (1998), valuable headway has been made in how the experience of apprehension or not following commission of a crime affects sanction risk perceptions. This research is valuable for specification of a theory that combines the concepts of general and specific deterrence. However, it does not address how perceptions are formed about the two key dimensions of a sanction regime: the legal authority for different types of sanctions and how that authority is administered. Numerous surveys have been conducted of the general public's knowledge of sanction regimes, especially concerning the legal authority for different types of sanctions (Apel 2013). Not surprisingly, the surveys find that knowledge of sanction regimes is poor. However, the fundamental flaw with these surveys is that knowledge of the potential legal consequences of lawbreaking is unnecessary for most people; their decisions to refrain from crime are based on the mere knowledge that the behavior is legally prohibited or for other nonlegal considerations such as morality or fear of social censure (Packer 1968; Zimring and Hawkins 1973; Andenaes 1974; Wikström et al. 2012). That said, for individuals for whom sanction threats might affect their behavior, it is preposterous to assume that their perceptions conform to the realities of the legally available sanction options and their administration. More than a decade after my

earlier review, it remains the case that little is known about how individuals form perceptions of the sanction regimes they confront.

This essay is organized in the following sections. Key concepts of deterrence are discussed in Section I, where I also set out a simplified model of deterrence that is referred to throughout the essay. Section II provides a brief summary of the themes, conclusions, and flaws of research on the deterrent effects of prison and the police up to about 1990. In Section III, I summarize the evidence on the deterrent effects of capital punishment. I discuss the capital punishment literature separately because of its distinctive features and salience. I then examine in Section IV post-1990 studies of the crime prevention effects of imprisonment and in Section V post-1990s studies of the police effects on crime. Section VI discusses the survey-based literature on the accuracy of sanction risk perceptions, their formation, and their relationship to self-reported criminality. Section VII offers conclusions.

I. Key Concepts

Deterrence is a theory of choice in which would-be offenders balance the benefits and costs of crime. Benefits may be pecuniary, as in the case of property crime, but may also involve intangible benefits such as defending one's honor, expressing outrage, demonstrating dominance, cementing a reputation, or seeking a thrill. The potential costs of crime are comparably varied. Crime can entail personal risk if the victim resists. It may also invoke pangs of conscience or shame (Braithwaite 1989). I am mainly concerned with offender responses to the costs that attend the imposition of official sanctions such as arrest, imprisonment, execution, fines, and other restrictions on freedom and liberty such as mandated drug testing or electronic monitoring.

The origins of most modern theories of deterrence can be traced to the work of the Enlightenment-era legal philosophers (Beccaria 1764; Bentham 1789). The motivation for their work was their mutual abhorrence of the administration of punishment without constructive purpose. For them the constructive purpose was preventing crime. As Beccaria observed, "it is better to prevent crimes than punish them" ([1764] 1986, p. 93). Beccaria and Bentham argued that there are three key ingredients to the deterrence process: the severity, certainty, and celerity of punishment. These concepts, particularly the certainty and severity of punishment, form the foundation of nearly all contemporary

theories of deterrence. The enduring impact of their thinking is remarkable testimony to their innovation.

The theory of deterrence is predicated on the idea that if state-imposed sanction costs are sufficiently severe, criminal activity will be discouraged, at least for some. Thus, one of the key concepts of deterrence is the severity of punishment. Severity alone, however, cannot deter. There must also be some possibility that the sanction will be incurred if the crime is committed. Indeed the argument that the probability of punishment, not severity, is the more potent component of the deterrence process goes back to Beccaria, who observed that "one of the greatest curbs on crime is not the cruelty of punishments, but their infallibility. . . . The certainty of punishment even if moderate will always make a stronger impression" ([1764] 1986, p. 58).

In the lifetimes of Beccaria and Bentham there was no criminal justice system as we know it. Punishment for lawbreaking was almost certainly less regular and more haphazard than it is today. Punishment in contemporary society, however, also still remains far from guaranteed. In order for a formal sanction—whether moderate or severe—to be imposed, the offender must first be apprehended, usually by the police.[1] He must next be charged and successfully prosecuted and, finally, sentenced by the judge. Successful passage through all of these stages is far from certain. The most important set of actors affecting certainty is the police: without detection and apprehension, there is no possibility of conviction or punishment. For this reason special attention is given to discussing what is known about the deterrent effect of police activities and presence.

The third conceptual component of the theory of deterrence advanced by Bentham and Beccaria is the swiftness of punishment, which Bentham referred to as celerity. Celerity is the least studied of the conceptual troika underlying deterrence theory. The theoretical basis for its effect on deterrence is ambiguous, as is the empirical evidence on its effectiveness. Even Beccaria seemed to base his case for celerity more on normative considerations of just punishment than on deterrence effectiveness. He observed that "the more promptly and the more closely punishment follows upon the commission of a crime, the more just and useful will it be. I say more just, because the criminal is

[1] Crime may also be sanctioned entirely outside of the criminal justice system through retaliation by the victim or by others on his or her behalf (Jacobs and Wright 2006).

thereby spared the useless and cruel torments of uncertainty, which increase with the vigor of imagination and with the sense of personal weakness" (Beccaria [1764] 1986, p. 36).

In 1968 economist Gary Becker published the first modern formalization of the Beccaria-Bentham conception of the deterrence process (Becker 1968). Since then, other formalizations have appeared in economics, criminology, law, and sociology—some in the form of mathematical models and others in the form of nonmathematical conceptual theories (Cornish and Clarke 1986).

For the purposes of this essay still another formalization is provided. I have two purposes. One is to provide a conceptual structure for framing results that are well established in the literature. The second is more ambitious. I earlier indicated that the seemingly greater deterrent effect of certainty rather than severity of punishment reflected a response to the certainty of apprehension. In this regard, I distinguished two distinct functions of the police: apprehending the perpetrators of crime and serving in a sentinel function that deters crime from happening in the first place. The second purpose is to formalize this distinction. In so doing I link situational crime prevention theory with deterrence theory.

Bentham's conception of criminal choice involved the would-be offender balancing the potential pains of punishment against the pleasures of the offense. In this spirit the model formalizes the decision of a would-be offender to victimize a potential criminal opportunity, whether that opportunity is a person in the form of a potential robbery victim or property that might be stolen or vandalized.

The choice model is depicted in figure 1. It distinguishes four possible outcomes if the target is victimized: the criminal act is successfully completed, the act is not successfully completed and the perpetrator is not apprehended, the act is not successfully completed and the perpetrator is apprehended but not convicted, and the act is not successfully completed and the perpetrator is both apprehended and convicted. The probability of each of these outcomes is determined by the following probabilities.

Perceived Probability of Successful Completion of the Act. This probability, which is denoted by P_s, measures the would-be offender's perception of the chances the target can be successfully victimized. This perception will be affected by how effectively the opportunity is protected. For property targets, the level of protection is determined by

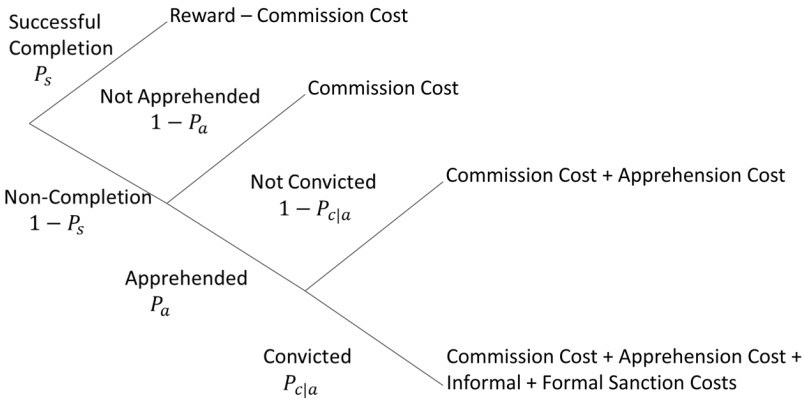

FIG. 1.—The decision to victimize a target

technological safeguards such as alarm and surveillance systems and use of physical protection such as locked showcases. For human targets, the protection level is affected by the care with which valuable property is secured, for example, by keeping it out of sight. Protection may also be provided by what Cohen and Felson (1979) call capable guardians such as security guards, vigilant employees, or onlookers who are willing to intervene. Importantly, the police may also serve as a guardian. I refer to police as acting as sentinels when acting in this role. An idling police car outside a liquor store greatly reduces the chance, probably to zero, that the store can be successfully robbed. This brings me to the risk of apprehension.

Perceived Probability of Apprehension Given Noncompletion. Police perform another crime control function that is distinct from their role as official guardians. They apprehend those offenders who chose to act on a criminal opportunity. When acting in this role, police are described as "apprehension agents." The sentinel and apprehension roles of the police are conceptually linked but distinct. They are conceptually linked because both roles are based on the legal authority of the police to arrest persons suspected of committing a crime. Because a contributing factor to P_s is the risk of apprehension, arrest authority is one source of police influence on P_s in their sentinel role. However, the sentinel role of police is distinct from their apprehension role because the latter comes into play only when deterrence has failed and a

would-be offender becomes an actual offender. Thus, at one moment police can be functioning as a sentinel and in the next moment they can be acting as an apprehension agent. The would-be offender's perception of the probability of apprehension given commission of the crime is denoted by P_a.

In this model I assume that the risk of apprehension is limited to acts that are not successfully completed. I make this assumption for several reasons. First, it is useful for clarifying the distinction between police acting as sentinels and police acting as apprehension agents. Second, it conforms to the seeming reality that most offenders are apprehended at the scene of the crime or soon thereafter. I say seeming because I have been able to identify only two studies (Greenwood, Chaiken, and Petersilia 1977; Blake and Coupe 2001) that report relevant data. Data reported in both support this assumption.

Perceived Probability of Conviction Given Apprehension. The offender's perception of the probability that apprehension will actually result in conviction is denoted by $P_{c|a}$.

Under this setup, the probability of successful completion is P_s, the probability of nonsuccessful completion but with apprehension avoidance is $(1 - P_s)(1 - P_a)$, the probability of nonsuccessful completion followed by apprehension but not conviction is $(1 - P_s)(P_a)(1 - P_{c|a})$, and the probability of nonsuccessful completion followed by apprehension and conviction is $(1 - P_s)(P_a)(P_{c|a})$.

The benefits and costs of each of these outcomes are assumed to be determined by the following factors:

- *Rewards.* Rewards measures the total benefits of victimizing a target. For a crime with a property motive, the value of the property to the perpetrator likely accounts for all or a major share of the total reward. However, the thrill of offending or—in the case of violent crimes without a property motive—the satisfaction of humiliating, physically hurting, or killing the victim may also be relevant to the reward value of a target.
- *Crime commission cost*. Crime commission cost measures the total cost of committing the crime separate from the sanction cost defined below. Commission cost includes time searching for the opportunity, planning time, if any, and the effort required to commit the crime itself. Importantly, it also includes the potential costs to the perpetrator of victim retaliation or resistance. Finally, commission cost includes Raskolnikov-like feelings of guilt or shame that

may affect the perpetrator, whether or not he is apprehended and sanctioned.

- *Perceived formal sanction cost*. Perceived sanction cost measures the would-be perpetrator's assessment of the formal sanction cost that might be imposed if convicted. These costs include the loss of freedom if imprisoned and the unpleasantness of other restrictions on freedom due to conditions of parole or probations and fines.
- *Perceived informal sanction cost.* The imposition of formal sanctions may also trigger informal sanctions by family, friends, and the community at large, which for some offenders may be even more costly than the formal sanctions. Informal sanction cost may also involve large economic costs due to job loss.
- *Perceived cost of apprehension.* Apprehension imposes costs that are distinct from formal and informal sanction costs. These include the unpleasantness of the apprehension itself, possible loss of liberty due to pretrial detention, and legal fees. Perceived cost of apprehension also includes the social and economic costs triggered by arrest, even without conviction, such as disapproval of family, friends, and the community at large, as well as job loss.

At the end of each branch, figure 1 shows the costs that attend the various forms of an unsuccessful attempt or the benefit of a successful attempt. If the individual chooses to act on a criminal opportunity, the benefits and costs of the four possible outcomes and their attendant probabilities are as follows:

1. The offender successfully completes the criminal act. This occurs with probability P_s, and the net benefit to the offender is reward less commission cost. Thus, the expected benefit of victimization is P_s(Reward − Commission Cost), which is denoted as $P_s(R - CC)$.
2. The offender is not successful and is not apprehended. This occurs with probability $(1 - P_s)(1 - P_a)$. The cost to the offender is that much, or all, of the commission cost is incurred but with no reward. For simplicity it is assumed that all of the commission cost is incurred. Thus, the contribution of this outcome to expected cost is $(1 - P_s)(1 - P_a)$(Commission Cost), which is denoted as $(1 - P_s)(1 - P_a)CC$.
3. The offender is not successful and is apprehended but is not convicted and formally sanctioned. This occurs with probability

$(1 - P_s)(P_a)(1 - P_{a|c})$. In this case the cost to the offender is commission cost plus apprehension cost. Thus the contribution of this outcome to expected cost is $(1 - P_s)(P_a)(1 - P_{c|a})$(Commission Cost + Apprehension Cost), which is denoted as $(1 - P_s)(P_a)(1 - P_{c|a})(CC + AC)$. Because, as already noted, most apprehensions occur at the scene of the crime or shortly thereafter, it is assumed that the perpetrator does not have the opportunity to enjoy the rewards provided by the act.

4. The offender is not successful but is apprehended, convicted, and formally sanctioned. This occurs with probability $(1 - P_s)(P_a)(P_{c|a})$. In this case the cost to the offender is commission cost plus apprehension cost plus formal and informal sanction cost. Thus, the contribution of this outcome to expected cost, again assuming that the rewards are not enjoyed, is $(1 - P_s)(P_a)[P_{c|a}$(Commission Cost + Apprehension Cost + Formal Sanction + Informal Sanction Cost)], which is denoted as $(1 - P_s)(P_a)(P_{c|a})(CC + AC + FS + ISC)$.[2]

An arrow at the top of figure 1 highlights that the possible events depicted occur over time. Success or failure at completion is typically immediate, whereas the down tree events occur later, often months after the criminal event in the case of conviction and sentencing. I return to this observation in the discussion of the celerity of punishment.

It is assumed that the crime will be committed if the expected benefits from a successful completion exceed the expected cost of an unsuccessful attempt, namely, if

$$P_s(R - CC) > (1 - P_s)(1 - P_a)CC + (1 - P_s)(P_a)(1 - P_{c|a})(CC + AC) + (1 - P_s)(P_a)(P_{c|a})(CC + AC + FS + ISC). \quad (1)$$

An equivalent form of this relationship moves P_s on the left-hand side to the right-hand side, in which case the crime will be committed if

$$(R - CC) > \left(\frac{1 - P_s}{P_s}\right)[(1 - P_a)CC + (P_a)(1 - P_{c|a})(CC + AC) + (P_a)(P_{c|a})(CC + AC + FS + ISC)]. \quad (2)$$

The left-hand side of equation (2) measures the net benefits of com-

[2] This model assumes that success precludes the possibility of subsequent apprehension and the attendant risk of formal sanction.

mitting the crime and the right-hand side measures the costs. Several observations about this relationship are relevant to the remainder of the discussion.

First, unless the net benefit of crime commission is positive (i.e., $R - C > 0$),[3] the offense will not be committed regardless of the formal and informal sanction costs specified on the right-hand side of equation (2). Particularly if commission cost is understood to include the shame of committing an act that involves taking another person's property or doing violence to that person, for most people sanction costs are irrelevant to the decision to refrain from crime. For example, Bachman, Paternoster, and Ward (1992) found in a study of sexual assault that sanction risk perceptions were relevant to self-reported intentions to offend only for the least morally committed. The absence of an effect for those with higher levels of moral commitment, however, should not be construed as their being impervious to incentives but to their moral commitment being a sufficient basis for refraining from sexual assault.[4] This elementary but fundamental point has been made repeatedly in the discussion about to the degree to which sanction threats affect behavior among different individuals. See, for example, Zimring and Hawkins (1973) and more recently Piquero et al. (2011) and Wikström et al. (2012). I return to this point in the discussion of sanction risk perceptions and their influence on behavior in Section VI.

Second, the bottom three branches of the tree pertain to the consequences of failure to complete the crime. Commission cost contributes to the total cost of all three of these branches, apprehension cost contributes to two of the three branches—apprehension with and without conviction—and informal and formal sanction costs contribute only to the final branch, apprehension with conviction. This implies that increases in perceived commission cost will have a greater deterrent effect than equal increases in either perceived apprehension cost or perceived formal and informal sanction costs. In turn the structure of the tree implies that increases in apprehension cost will have a greater deterrent effect than equal increases in either formal or informal sanction cost. This observation helps to explain the longstanding conclusion from the perceptual deterrence literature that shame, a key component of commission cost and apprehension cost, plays a more

[3] Rewards and commission cost may also be affected by risk preferences.

[4] Knowledge of potential punishment may also reinforce a normative sense of wrongfulness.

decisive role in the deterrence process than sanction cost. This issue is discussed further in Section III. It also explains the seeming effectiveness of situational crime prevention tactics, a topic I allude to in Section V.

Third, the structure of the tree also implies that decreases in P_s will have larger deterrent effects than equal-sized increases in either P_a or $P_{s|a}$ and that increases in P_a will have a bigger deterrent impact than an equal increase in $P_{s|a}$. This observation is consistent with the longstanding belief dating back to Beccaria that the certainty of punishment is a more effective deterrent than the severity of punishment. However, I earlier noted that the evidence suggests that a more precise statement of the certainty conclusion pertains to the certainty of apprehension. The decision model laid out here provides a still more precise statement of that conclusion. Decreases in P_s provide more effective deterrence than equal increases in P_a. Concerning the distinction between police serving as sentinels or as apprehension agents, when serving in their role as sentinels, they affect P_s, whereas when serving as apprehension agents, they affect P_a. This implies that the sentinel role of policing is more effective in deterring crime than their apprehension agent role. This observation is relevant to the discussion in Section V of the varying findings on police effectiveness in preventing crime.

II. Deterrence Research to the 1990s

Empirically based deterrence research began in earnest in the late 1960s. There were three major instigators. One was technological: the growing availability of computers and statistical software for analyzing crime data, which were also growing in availability. The second was social: the steady growth of crime rates during the 1960s. The third was intellectual, especially within economics, with the publication in 1968 of Becker's seminal article "Crime and Punishment: An Economic Approach."

Deterrence studies up to the 1990s are usefully grouped into three categories: experimental and quasi-experimental studies, aggregate studies, and perceptual deterrence studies. My 1998 *Crime and Justice* review provided an extended discussion of the three types of studies (Nagin 1998). This section summarizes conclusions of the experimental and quasi-experimental studies and aggregate studies of this research era that are most relevant to this review. Because of the persistence of

themes in the pre- and post-1990s perceptual deterrence research and the continuity of the research methods used, I discuss this body of research without reference to era in Section VI.

A. Experimental and Quasi-Experimental Studies

This category of studies examines the effect of targeted policy interventions such as police crackdowns or implementation of statutes changing penalties. In the experimental studies the intervention and control treatments are randomly assigned. A classic example is the Minneapolis Domestic Violence Experiment (Sherman and Berk 1984) in which police responded to misdemeanor incidents of domestic violence with one of three randomly chosen responses. The arrest response was found to be most effective in preventing recidivism, but as discussed in Section V, this finding was not consistent across replications of the experiment in other localities.

True experiments, however, compose only a small fraction of the studies in this category. Most are quasi experiments. The best-designed quasi-experimental studies attempt to incorporate important features of a true experiment: a well-defined treatment regime, measurement of response before and after treatment, and a control group. Two classic studies of this genre are Ross's studies of the effects on drunk driving of the British Road Safety Act (Ross 1973) and of Scandinavian-style drunk driving laws. Most studies in this group examine the effects of police crackdowns on drug markets, disorderly behavior, and drunk driving. Excellent reviews of these studies are available in Sherman (1990) and Ross (1982). Both Sherman and Ross conclude that the interventions were generally successful in generating an initial deterrent effect. For instance, in drunk-driving interventions, this was evidenced by a reduction in fatalities in which the driver was intoxicated or in drug market crackdowns by reduced dealing. However, they also concluded that the effect was generally only transitory: the initial deterrent effect typically began decaying even while the intervention was in effect. One exception to this finding of at least initial deterrent effectiveness concerned studies of increases in sentence severity. Ross (1982) discusses the ineffectiveness of severity enhancements in three very different places: Finland, Chicago, and New South Wales, Australia. Evidence even of an initial effect is less consistent than in studies of interventions that increased the certainty of apprehension.

I take away three important lessons from this literature. First, the

generally more consistent findings of initial effectiveness in the apprehension-based interventions, compared to the severity-based interventions, provide more evidence in support for my modified version of the certainty effect, namely, that certainty of apprehension is a more effective deterrent than the severity of the ensuing legal consequences, but with an important proviso. Ross (1982) attributed the ineffectiveness of severity-enhancing policies to the fact that they trigger a system response that reduced certainty of punishment. He pointed out that if judges or juries believed the penalties too harsh, they may have responded by refusing to convict guilty defendants. Police and prosecutors may respond similarly. Thus, any potential deterrent effect of the severity enhancement may be canceled by the reduction in certainty. This result is a reminder not only of the difficulty of enforcing penalties that are deemed unjust but also that certainty and severity do not operate independently—they interact. Tonry (2009) forcefully elaborates on many of these points.

Second, Sherman (1990) offers useful nomenclature for describing the finding of only transitory effects. He uses the term "initial deterrence decay" to describe the decline in the deterrent response as "potential offenders learn through trial and error that they had overestimated the certainty of getting caught at the beginning of the crackdown" and "residual deterrence," which is a crime suppression effect that extends beyond the intervention until offenders learn by experience or word of mouth that "it is once again 'safe' to offend" (p. 10). Sherman's observations are a reminder that deterrence is a perceptual phenomenon. In Sherman (1990) and Nagin (1998), we both discuss the decay of initial deterrence as a possible response to what behavioral economists call ambiguity aversion. People consistently prefer gambles in which the risks are clearly comprehensible compared to equivalent gambles in which the risks are less transparent. Initial deterrence may be a response to perceptions of uncertainty about true risk rather than to any change in the true risk of apprehension. Thus, unless policy can affect perceptions, there will be no behavioral response. It is also a reminder that perceptions may be updated in response to cues from the environment and therefore will not necessarily be stable. I return to this important issue in the discussion of the perceptions studies in Section VI.

Third, the findings from these studies have stood the test of time. In my judgment, well-conducted experimental and quasi-experimental

studies of deterrence provide the most convincing evidence of the circumstances under which deterrence is and is not effective. This holds for both the post-1990s and the pre-1990s literatures.

B. Aggregate Studies

The pre-1990s aggregate studies generally analyzed the association of crime rates across geographic units, usually states, with measures of the certainty and severity of punishment. The most basic form of these analyses involved bivariate correlations across states of crimes rates for the crime categories composing the FBI part I crime index (e.g., murder and nonnegligent homicide, robbery, burglary) with certainty of punishment, measured by prison admissions per reported crime, and severity of punishment, measured by median time served. More elaborate analyses were conducted in a regression format. These analyses added various state characteristics known to be correlated with crime (e.g., age and racial composition, urbanization) to the base regression model relating crime rate to the certainty and severity measures. Negative and significant associations were generally found between the crime rate and the certainty of imprisonment ratio. The association of time served with the crime rate was generally insignificant.

Reviews of these studies, including a high-visibility National Research Council (NRC) report (Blumstein, Cohen, and Nagin 1978), concluded that the aggregate studies suffered from such grave flaws that they did not provide a basis for valid inference about deterrent effects. Two flaws are particularly noteworthy because they remain relevant to the interpretation of a successor strand of post-1990 aggregate studies discussed in Section IV. The first is that the associations do not distinguish the behavioral response to sanction threats, deterrence, from incapacitation. The second is more fundamental—distinguishing cause from effect. All forms of nonexperimental data are vulnerable to the criticism that the outcome of interest, in this case the crime rate, is the cause of the predictor of interest, in this case sanctions, and not vice versa. High crime rates, for example, might prompt a police crackdown followed by crime rates declining for other reasons. Cross-polity studies of natural variations in crime rates and sanction levels are particularly vulnerable to this concern because there is generally no basis for assessing whether the variations in sanction levels are the result of factors independent of the crime rate. By contrast, for quasi-experi-

mental studies, institutional research can reveal whether the intervention was prompted by rising crime rates.

III. Capital Punishment

Studies of the deterrent effect of capital punishment have been and continue to be the source of bitter contention. Isaac Ehrlich's 1975 study, in which he concluded that each execution averted seven to eight homicides, is undoubtedly the most-cited study of this kind. The 1978 NRC report (Blumstein, Cohen, and Nagin 1978) and an accompanying commissioned paper (Klein, Forst, and Filatov 1978) laid out a lengthy list of criticisms of the Ehrlich analysis. The NRC report concluded that "available studies [including Ehrlich's] provide no useful evidence on the deterrent effect of capital punishment" (p. 9).

Coincidentally, that report was issued shortly after the 1976 Supreme Court decision *Gregg v. Georgia* ended the moratorium on execution in the United States. In the 35 years since publication of the 1978 report, and more especially in recent years, a considerable number of post-*Gregg* studies have attempted to estimate the effect of the legal status or the actual implementation of the death penalty on homicide rates. These studies have reached widely varying conclusions and have resulted in often bitter disagreement about their interpretation.

This more recent literature has been the subject of still another NRC report titled *Deterrence and the Death Penalty*, which I coedited (Nagin and Pepper 2012), as well as two reviews of the literature commissioned by the NRC committee (Chalfin, Haviland, and Raphael 2013; Charles and Durlauf 2013) and two valuable reviews by Donohue and Wolfers (2005, 2009). The NRC report and all of the reviews are highly critical of the post-*Gregg* research. The report concluded, "Research to date on the effect of capital punishment on homicide is not informative about whether capital punishment decreases, increases, or has no effect on homicide rates. Therefore, the Committee recommends that these studies not be used to inform deliberations requiring judgments about the effect of the death penalty on homicide. Consequently, claims that research demonstrates that capital punishment decreases or increases the homicide rate by a specified amount or has no effect on the homicide rate should not influence policy judgments about capital punishment" (Nagin and Pepper 2012, p. 3).

The NRC report leveled two key criticisms of the post-*Gregg* capital

punishment deterrence research that transcend the high-profile but still narrow issue of the deterrent effect of capital punishment. They also apply to studies of the deterrent effect of other forms of sanction—prison, fines, and community control—that form the backbone of contemporary sanction policy in the United States and most other countries.

One criticism concerned the incomplete specification of the sanction regime for homicide. Even for capital-eligible convictions for homicide, only a minority of cases result in a sentence of death, let alone an execution (Nagin and Pepper 2012). This is true even for states such as Texas and Virginia that make the most intense use of capital punishment. Instead, most homicides result in a lengthy prison sentence, sometimes life without parole. A study by Cook (2009) illustrates this point. Of 274 cases prosecuted as capital cases, only 11 resulted in a death sentence. Another 42 resulted in dismissal or a verdict of not guilty, which left 221 cases resulting in conviction and sentences to a noncapital sanction.

None of the post-*Gregg* studies take into account the noncapital component of the sanction regime. As discussed in Nagin and Pepper (2012) and Chalfin, Haviland, and Raphael (2013), there are sound reasons for expecting that the severity of the noncapital sanctions for homicide varies systematically with the availability and the intensity of use of capital punishment. For example, the political culture of a state may affect the frequency of use of capital punishment and also the severity of noncapital sanctions for homicide. Thus, any effect that these noncapital sanctions have on homicide may contaminate the estimated effect of capital punishment on homicide. In capital punishment studies the potential for such bias is particularly strong because, as noted, noncapital sanctions remain the dominant sanction response to capital-eligible murders, even in states that make the most intense use of capital punishment.

Homicide is not the only criminal offense punishable by a range of qualitatively different sanction alternatives. Indeed the sanction regimes for most other criminal offenses, even felonies, include more than one sanction option for their punishment. This point is returned to in Section IV.

A second key criticism elaborated in the NRC report concerned the specification of perceptions of the capital punishment component of the sanction regime. Studies typically suppose that people who are con-

templating murder perceive sanction risks as subjective probabilities of arrest, conviction, and execution. Lacking data on these subjective probabilities, researchers presume that they are somehow based on the observable frequencies of arrest, conviction, and execution.

The report concluded that several factors made the attempts by the panel studies to specify the capital component of state sanction regimes uninterpretable. First, the findings are very sensitive to the way in which the risk of execution is specified. For example, because of delays between the imposition of a death sentence and its being carried out, if ever, researchers routinely computed ratios in which the numerator was the number of executions in a given state and year divided by the number of death sentences imposed in that state in some prior year. Results are very sensitive to how that ratio is computed (Chalfin, Haviland, and Raphael 2013), and there is no logical basis for resolving disagreements about how the true risk of execution should be measured. Among the difficulties is that only 15 percent of those sentenced to death in the United States since 1977 have been executed, with close to 40 percent leaving death row for other reasons (vacated sentences or convictions, commutations, a successful appeal, or death by other causes) and 45 percent still awaiting execution (Snell 2010). Available information for calculating the risk depends on the size of the state: for large states such as Texas and California, there are far more data for calibrating risk than for small states such as Delaware and Montana. Further complicating matters, policies can change as a result of court decisions and administrative decrees of elected officials. This unpredictability calls into question the usefulness of prior data on the death penalty when calculating present and future risk. Because none of the measures used has any clear relationship with the correct measure, there is no reasoned basis for arbitrating competing claims about which study provides the better estimate of the deterrent effect of the death penalty.

Even if it were possible to judge which measure more closely corresponds to true risk, there is no evidence that the perceptions of potential murderers correspond to this risk. The above discussion concerns only one aspect of sanction regime, the risk of execution given conviction. Other relevant dimensions of the sanction regime are the risk of conviction given commission of a murder and the certainty and severity of the noncapital component alternatives to the death penalty. The assumption that potential murderers have accurate perceptions of

these risks and consequences is not credible: indeed it is preposterous. I return to the issue of sanction risk perceptions in Section VI.

IV. Imprisonment and Crime

There have been two distinct waves of aggregate studies of the relationship between imprisonment and crime. Studies in the 1960s and 1970s described in Section II examined associations of state-level crime rates to state-level certainty of punishment, measured by the ratio of prison admissions to reported crimes, and to state-level severity of punishment as measured by median time served. These studies suffered from fundamental deficiencies laid out in the 1978 NRC report (Blumstein, Cohen, and Nagin 1978) and elsewhere. As a consequence, aggregate-level deterrence research went largely "silent" for more than a decade.

A. Post-1990s Aggregate Studies

By the mid-1990s, a second generation of studies emerged. Unlike the first-generation studies, which primarily involved cross-sectional analyses of states, second-generation studies had a longitudinal component in which data were analyzed across states and over time. Another important difference in the second-generation studies is that they did not attempt to estimate certainty and severity effects separately. Instead they examined the relationship between the crime rate and the rate of imprisonment as measured by prisoners per capita.

A review by Donohue (2009) identifies six studies of the relationship of crime rates to imprisonment rates. All find statistically significant negative associations between imprisonment rates and crime rates, implying a crime prevention effect for imprisonment. However, the magnitude of the estimate varied widely: from nil for a study that allowed for the possibility that prevention effects decline as the scale of imprisonment increases (Liedka, Piehl, and Useem 2006) to −0.4 percent for each 1 percent increase in the imprisonment rate (Spelman 2000).

Apel and Nagin (2009), Donohue (2009), and Durlauf and Nagin (2011*a*, 2011*b*) discuss important flaws in these studies. One is that they are necessarily measuring the combined effect of deterrence and incapacitation on crime rates and thus cannot be interpreted as measuring the deterrent effect of imprisonment. At best they can be said to estimate the upper bound of that effect.

Other shortcomings are even more fundamental. One concerns the same fundamental flaw of the first-generation studies—distinguishing cause from effect. While imprisonment prevents crime through a combination of deterrence and incapacitation, crime also generates the prison population. The object of interest is the effect of the imprisonment rate on the crime rate, but data available for estimation of that effect also reflect the effect of the crime rate on the imprisonment rate. Thus, statistical isolation of the crime prevention effect requires properly accounting for the effect of crime on imprisonment.

The shortcomings in the statistical strategies used in these studies to identify the crime prevention effect of imprisonment are discussed at length in Durlauf and Nagin (2011*a*, 2011*b*). To summarize, with the exception of Levitt (1996) and Johnson and Raphael (2012), the conclusions of the studies rest on a form of statistical analysis pioneered by the Nobel laureate Clive Granger (1969). Granger's method is often mistakenly interpreted as providing estimates with a causal interpretation, which in the context of the aggregate imprisonment studies would be the expected change in the crime rate resulting from a policy that changes the imprisonment rate by a specified amount. In fact, the results are not in general amenable to this interpretation. Instead, application of Granger's method provides only a basis for forecasting future changes in the crime rate as a function of prior changes in the imprisonment rate and the crime rate. While valid forecasts can be based on correlations alone, valid causal interpretation requires more than establishing correlation.

Figure 2 illustrates the problem. Panel *A* depicts hypothetical crime and imprisonment functions. The crime function $C(I)$ describes the crime rate as a function of the imprisonment rate, I, and the imprisonment function $I(C)$ measures the imprisonment rate as a function of the crime rate, C. The function $C(I)$ is shown to be downward sloping in I to reflect the crime reduction effects of imprisonment via some combination of deterrence and incapacitation. Studies of the relationship of the crime rate to the imprisonment rate aim to measure whether this line is in fact downward sloping and, if so, by how much. The function $I(C)$ is depicted as upward sloping because for any fixed set of policies determining the certainty and severity of punishment, imprisonment rates will be a rising function of the crime

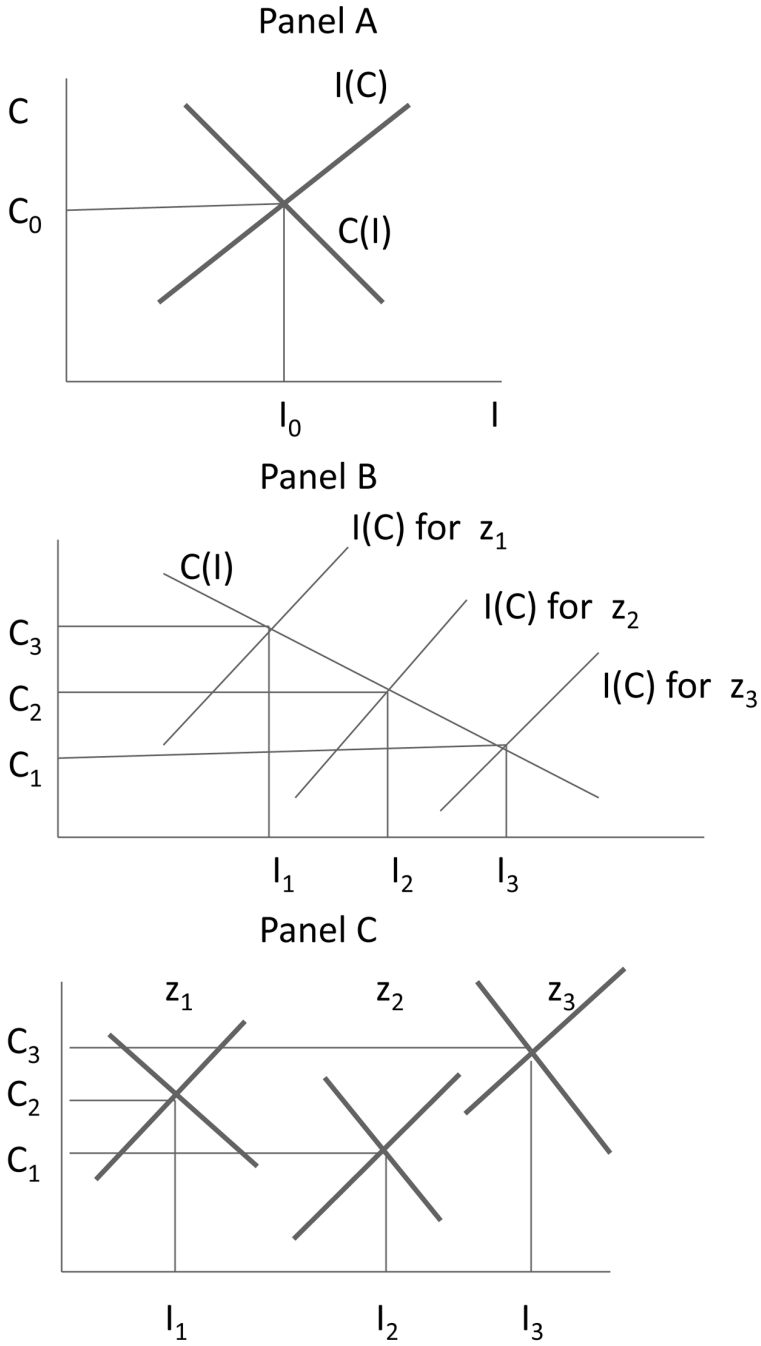

FIG. 2.—The challenge of identifying the effect of the imprisonment rate on the crime rate

rate.[5] The intersection of the $C(I)$ and $I(C)$ functions at I_0 and C_0 measures the observed level of crime and imprisonment.

Crime rates and imprisonment rates are, of course, affected by a multitude of other factors beyond their mutual interaction as depicted in panel *A*. The key to estimating $C(I)$ is identifying some factor, called an instrumental variable (IV), that is thought to affect the imprisonment rate but that affects the crime rate only via its effect on shifting the location of imprisonment rate function. Suppose that such an IV were identified and denoted by z. Panel *B* demonstrates how changing values of z from z_1 to z_2 to z_3 shifts the $I(C)$ function and, in so doing, traces out the $C(I)$ function. Connecting the points (I_1, C_1), (I_2, C_2), and (I_3, C_3) estimates $C(I)$. In this fashion, IV regression models can be said to identify $C(I)$ and thereby the crime reduction effect of the imprisonment rate on the crime rate. However, the key to IV regression successfully isolating this effect is that $C(I)$ is not directly affected by z. Panel *C* illustrates the failure of this assumption. If z also shifts $C(I)$, the changing equilibrium values of the imprisonment rate and crime rate no longer trace out the $C(I)$ function.

Only Levitt (1996) and Johnson and Raphael (2012) use an IV regression approach to identify the causal effect of imprisonment on crime. Levitt uses court-ordered prison releases to form a set of IVs. He argues that such court orders meet the test for providing a valid estimate of the effect of the imprisonment rate on the crime rate: the orders have no direct effect on the crime rate and affect it only insofar as the court orders affect the imprisonment rate, which in turn affects the crime rate.

Even if one accepts this argument, the estimated effect has only limited policy value. By its construction, it is likely measuring the effect on crime of the early release of selected prisoners, probably those nearing the end of their sentenced terms. It may also be reflecting the effect of diversion of individuals convicted of less serious crimes either to local jails or to community supervision. In either case, the estimates are not informative about the crime prevention effects, whether by deterrence or incapacitation, of sentence enhancements related to the

[5] As in the entire imprisonment and crime literature, I too assume that sanction policies are unaffected by either the crime rate or the imprisonment rate. This is not a tenable assumption. However, all the points I make in the ensuing discussion would continue to hold if the model were generalized to allow sanction policy to be affected by crime rates and imprisonment rates.

manner in which a crime is committed (e.g., weapon use), the characteristics of the perpetrator (e.g., prior record), or policies affecting the likelihood of incarceration. More generally, the uncertainty about what is actually being measured inherently limits the value of the estimated effects for both policy and social science.

A more recent study by Johnson and Raphael (2012) is based on a technically complex IV regression model. Identification is based on the assumption that prison populations do not change instantaneously in response to changes in the size of the criminal population. Similarly to the non-IV-based analysis of Liedka, Piehl, and Useem (2006), Johnson and Raphael conclude that the crime prevention effect of imprisonment has diminished with the scale of imprisonment, which was rising steadily over the period of their analysis, 1978–2004.

One explanation for the Johnson and Raphael finding is that the states and the federal government over this period collectively implemented policies with steadily declining average deterrent effectiveness. Given that knowledge of the deterrent effectiveness of alternative sanction policies is so limited, this explanation is not credible. An alternative explanation involving incapacitation is more credible. If the crime reduction effect of incarceration primarily stems from incapacitation, the Johnson and Raphael finding is consistent with the concept of "stochastic selectivity" (Canela-Cacho, Blumstein, and Cohen 1997), whereby high-rate offenders are more likely to be apprehended and incarcerated than low-rate offenders. Thus, as the scale of imprisonment increases, higher-rate offenders will be less likely to be at large committing crimes. Johnson and Raphael's finding is replicated by Vollaard (2013) in an analysis of the Netherlands' Habitual Offender Law. Vollaard attributes the entirety of the crime prevention effect that he estimates to incapacitation. Also of note, Owens (2009) in her analysis of 2003 data from Maryland finds modest incapacitation effects.

The incapacitation interpretation of the Johnson and Raphael finding of decreasing crime prevention returns with the scale of imprisonment is more credible than the deterrence interpretation. This interpretation also implies that the study is not useful for learning about deterrence. However, even the incapacitation interpretation is cast in doubt by the aging of the US prison population. Between 1991 and 2010, the percentage of prisoners in state and federal prisons over 45 years old has nearly tripled from 10.6 percent to 27.4 percent (Bureau of Justice Statistics 1999, 2011). Thus, the seeming decline in the in-

capacitative effectiveness of prison with scale may be reflecting only the aging of the prison population, which coincides with rising imprisonment rates. Further complicating the decreasing returns interpretation is the changing composition of the prison population in terms of the composition of prisoner conviction offense. Over the past four decades, the percentage of prisoners incarcerated for non–part I FBI index crimes has increased substantially (Blumstein and Beck 1999, 2005). Thus, the reduction in crime prevention effectiveness may be due to the types of prisoners incarcerated, not to scale effects.

All of these studies, whether IV based or not, also suffer from an important conceptual flaw that limits their usefulness in understanding deterrence and devising crime control policy. Prison population is not a policy variable per se; rather, it is an outcome of sanction policies dictating who goes to prison and for how long, namely, the certainty and severity of punishment. In all incentive-based theories of criminal behavior, in the tradition of Bentham and Beccaria, the deterrence response to sanction threats is posed in terms of the certainty and severity of punishment, not in terms of the imprisonment rate. Therefore, to predict how changes in certainty and severity might affect the crime rate requires knowledge of the relationship of the crime rate to certainty and severity as separate entities, which is not provided by the literature that analyzes the relationship of the crime rate to the imprisonment rate.

The studies are also conducted at a too-global level. In Nagin (1998), I describe the two-dimensional taxonomy of sanction policies affecting the scale of imprisonment. One dimension labeled "type" distinguishes three broad categories: policies regulating certainty of punishment such as laws requiring mandatory imprisonment, policies influencing sentence length such as determinate sentencing laws, and policies regulating parole powers. The second dimension of the taxonomy, "scope," distinguishes policies that cast a wide net, such as a general escalation of penalties for broad categories of crime, compared to policies that focus on targeted offenses (e.g., drug dealing) or offenders (e.g., three-strikes laws).

The nearly 500 percent growth in prison population over the last two decades is attributable to a combination of policies belonging to all cells of this matrix. Parole powers have been greatly curtailed; sentence lengths increased, both in general and for particular crimes (e.g., drug dealing); and judicial discretion to impose nonincarcerative sanc-

tions has been reduced (Tonry 1996; Blumstein and Beck 1999, 2005; Raphael and Stoll 2009). Consequently, any effect on the crime rate of the increase in prison population reflects the effects of an amalgam of potentially interacting treatments.

There are good reasons for predicting differences in the crime reduction effects of different types of sanctions (e.g., mandatory minimums for repeat offenders vs. prison diversion programs for first-time offenders). Obvious sources of heterogeneity in offender response include factors such as prior contact with the criminal justice system, demographic characteristics, and the mechanism by which sanction threats are communicated to their intended audience. Indeed, available evidence on the deterrent effect of sentence enhancements, the next topic of discussion, demonstrates such heterogeneity.

B. Policy Evaluation Studies of Sentence Enhancements

There have been comparatively few studies of the deterrent effects of sentence enhancements, judged relative to their importance in contemporary crime control policy. The earliest post-1970s attempts to measure severity effects analyzed the deterrent impact of sentence enhancements for gun crimes. In a series of studies, Loftin, McDowell, and colleagues (Loftin and McDowall 1981, 1984; Loftin, Heumann, and McDowall 1983) examined whether sentence enhancements for gun use in committing another type of crime such as robbery deter gun use in the commission of crime. While the findings are mixed, this body of research has generally failed to uncover evidence of a deterrent effect (but see McDowall, Loftin, and Wiersema 1992).

However, one important caveat remains with respect to extrapolating these studies to understanding the link between deterrence and severity. The same literature that found that gun penalty enhancements were ineffective also found that these laws generally failed to increase the sentences actually received in gun-related crime prosecutions. Thus, gun-using criminals may not have responded because the real incentives were not changed. This again is a reminder of Tonry's (2009) commentary on the highly inconsistent administration of mandatory minimum sentencing.

Kessler and Levitt (1999) examine the deterrent impact of another California sentence enhancement law, Proposition 8, passed in 1982. Proposition 8 anticipated the three-strikes laws passed by many states in the 1990s. They estimate a 4 percent decline in crime attributable

to deterrence in the first year after enactment. Within 5–7 years, the effect grows to a 20 percent reduction. As acknowledged by Kessler and Levitt, the longer term estimate includes incapacitation effects.

Webster, Doob, and Zimring (2006) challenged the basic finding of any preventive effects. Kessler and Levitt examine data from every other year. When all annual data are used, Webster, Doob, and Zimring find that the decline in crime rates in the affected categories begins before Proposition 8's enactment, and the slope of this trend remains constant through implementation. But see Levitt (2006) for a response and commentary supporting Webster et al. by Raphael (2006).

One exception to the scarcity of studies on the crime prevention effects of sentence enhancements concerns analyses of the deterrent effect of California's "three strikes, you're out" law, which mandated a minimum sentence of 25 years upon conviction for a third-strike offense. Zimring, Hawkins, and Kamin (2001) concluded that the law reduced the felony crime rate by at most 2 percent. They also conclude that only those individuals with two convictions for two offenses qualifying as "strikes" showed any indication of reduced offending. Other studies by Stolzenberg and D'Alessio (1997) and Greenwood and Hawken (2002), who like Zimring, Hawkins, and Kamin (2001) examine before and after trends, conclude that the crime prevention effects were negligible.

I turn now to six studies that in my judgment report particularly convincing evidence on the deterrent effect of incarceration. They also nicely illustrate heterogeneity in the deterrence response to the threat of imprisonment.[6] Weisburd, Einat, and Kowalski (2008) and Hawken and Kleiman (2009) study the use of imprisonment to enforce fine payment and conditions of probation, respectively, and find substantial deterrent effects; Helland and Tabarrok (2007) analyze the deterrent effect of California's third-strike provision and find a modest deterrent effect; Raphael and Ludwig (2003) examine the deterrent effect of prison sentence enhancements for gun crimes and find no effect; and Hjalmarsson (2009) and Lee and McCrary (2009) examine the heightened threat of imprisonment that attends coming under the jurisdiction of the adult courts at the age of majority and find no deterrent effect.

Weisburd, Einat, and Kowalski (2008) report on a randomized field

[6] For further discussion of heterogeneity in deterrence response, see Paternoster (2010) and Piquero et al. (2011).

trial of alternative strategies for incentivizing the payment of court-ordered fines. The most salient finding involves the "miracle of the cells," namely, that the imminent threat of incarceration provides a powerful incentive to pay delinquent fines, even when the incarceration is for only a short period. The miracle of the cells provides a valuable perspective on the conclusion that the certainty, rather than the severity, of punishment is the more powerful deterrent. Consistent with the "certainty principle," the common feature of treatment conditions involving incarceration is a high certainty of imprisonment for failure to pay the fine. However, that Weisburd et al. label the response the "miracle of the cells" and not the "miracle of certainty" is telling. Their choice of label is a reminder that certainty must result in a distasteful consequence in order for it to be a deterrent. The consequences need not be draconian, just sufficiently costly, to deter the proscribed behavior.

The deterrence strategy of certain but nondraconian sanctions has been applied with apparently great success in Project HOPE, an intervention heralded in Hawken and Kleiman (2009), Kleiman (2009), and Hawken (2010). Project HOPE is a Hawaii-based probation enforcement program. In a randomized experiment, probationers assigned to Project HOPE had much lower rates of positive drug tests and missed appointments and—most importantly—were significantly less likely to be arrested and imprisoned. The cornerstone of the HOPE intervention was regular drug testing, including random tests, and certain but short punishment periods of confinement (e.g., 1–2 days) for positive drug tests or other violation of conditions of probation. Thus, both the Weisburd, Einat, and Kowalski (2008) fine experiment and Project HOPE show that highly certain punishment can be an effective deterrent in cases in which deterrence has previously been ineffective in averting crime.

Helland and Tabarrok (2007) examine whether California's "three strikes, you're out" law deters offending among individuals previously convicted of strike-eligible offenses. The future offending of individuals convicted of two previous eligible offenses was compared with that of individuals who had been convicted of only one eligible offense but who, in addition, had been tried for a second eligible offense but were ultimately convicted of a noneligible offense. The two groups of individuals were comparable on many characteristics such as age, race, and time in prison. Even so, Helland and Tabarrok find that arrest

rates were about 20 percent lower for the group with convictions for two eligible offenses. The authors attribute this to the greatly enhanced sentence that would have accompanied conviction for a third eligible offense.

Raphael and Ludwig (2003) examine the deterrent effect of sentence enhancements for gun crimes that formed the basis for a much publicized Richmond, Virginia, federal program called Project Exile. Perpetrators of gun crimes, with a particular emphasis on those with a felony record, were the targets of federal prosecution that provided for far more severe sanctions for weapon use than were provided by Virginia state law. In a careful and thorough analysis involving comparisons of adult homicide arrest rates with juvenile homicide arrest rates within Richmond and comparisons of gun homicide rates between Richmond and other cities with comparable pre-intervention homicide rates, Raphael and Ludwig conclude that the threat of an enhanced sentence had no apparent deterrent effect.

For most crimes, the certainty and severity of punishment increase discontinuously upon reaching the age of majority, when jurisdiction for criminal wrongdoing shifts from the juvenile to the adult court. In an extraordinarily careful analysis of individual-level crime histories from Florida, Lee and McCrary (2009) attempt to identify a discontinuous decline in offending at age 18, the age of majority in Florida. Their point estimate of the discontinuous change is negative as predicted but is minute in magnitude and not even remotely close to achieving statistical significance.[7]

Another analysis of the effect, if any, of moving from the jurisdiction of the juvenile to adult courts by Hjalmarsson (2009) uses the 1997

[7] The finding that the young fail to respond to changes in penalties associated with the age of majority is not uniform across studies. An earlier analysis by Levitt (1998) finds a large drop in the offending of young adults when they reach the age of jurisdiction for adult courts. For several reasons, Durlauf and Nagin (2011*a*, 2011*b*) judge the null effect finding of Lee and McCrary (2009) more persuasive in terms of understanding deterrence. First, Levitt focuses on differences in age measured at annual frequencies, whereas Lee and McCrary measure age in days or weeks. At annual frequencies, the estimated effect is more likely to reflect both deterrence and incapacitation; hence Levitt's results may be driven by incapacitation effects rather than by deterrence per se. Second, the Lee and McCrary analysis is based on individual-level data and so avoids problems that can arise because of aggregation (Durlauf, Navarro, and Rivers 2008; Durlauf and Nagin 2011*a*). On their own terms, the individual-level data studied by Lee and McCrary are unusually informative since they also contain information on the exact age of arrestees, which allows for the calculation of very short-run effects of the discontinuity in sentence severity, e.g., effects within 30 days of turning 18.

National Longitudinal Survey of Youth to examine whether young males' perception of incarceration risk changed at the age of criminal majority. Youths were asked, "Suppose you were arrested for stealing a car; what is the percent chance that you would serve time in jail?" She found that subjective probabilities of being sent to jail increased discontinuously on average by 5.2 percentage points when youths reached the age of majority in their state of residence. While youths perceived an increase in incarceration risk, she found no convincing evidence of an effect on their self-reported criminal behavior.

C. Summary

In combination, these six studies demonstrate that debates on the effectiveness of deterrence are poorly conceived. Instead, the discussion should be framed in terms argued by Beccaria and Bentham more than two centuries ago: Does the specific sanction deter or not, and if it does, are the crime reduction benefits sufficient to justify the costs of imposing the sanction? Helland and Tabarrok's (2007) study is an exemplar of this type of analysis. They conclude that California's third-strike provision does indeed have a deterrent effect, a point even conceded by Zimring, Hawkins, and Kamin (2001). However, Helland and Tabarrok also conclude, on the basis of a cost-benefit analysis, that the crime-saving benefits are so much smaller than the increased costs of incarceration that the lengthy prison sentences mandated by the third-strike provision cannot be justified by means of a cost-benefit criterion.

The six exemplar studies suggest several important sources of the heterogeneity of the deterrent effect of imprisonment. One concerns the length of the sentence itself. Figure 3 depicts two alternative forms of the response function relating crime rate to sentence length. Both are downward sloping, which captures the idea that increases in severity deter crime. At the status quo sentence length, S_1, the crime rate, C_1, is the same for both curves. The curves are drawn so that they predict the same crime rate for a zero sanction level. Thus, the absolute deterrent effect of the status quo sanction level is the same for both curves. But because the two curves have different shapes, they also imply different responses to an incremental increase in sentence level to S_2. The linear curve (*A*) is meant to depict a response function in which there is a material deterrent effect accompanying the increase to S_2, whereas the nonlinear curve (*B*) is meant to depict a small crime

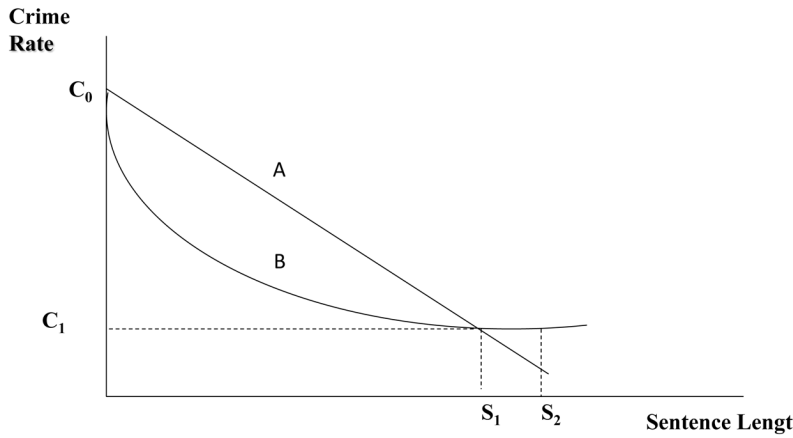

FIG. 3.—Marginal versus absolute deterrent effects

reduction response due to diminishing deterrent returns to increasing sentence length.

My reading of the evidence on the deterrent effect of sentence length is that it implies that the relationship between crime rate and sentence length more closely conforms to curve *B* than to curve *A*. Raphael and Ludwig (2003) find no evidence that gun crime enhancement deters, Hjalmarsson (2009) and Lee and McCrary (2009) find no evidence that the greater penalties that attend moving from the juvenile to the adult justice systems deter, and Helland and Tabarrok (2007) find only a small deterrent effect from California's third strike. As a consequence, the deterrent return to increasing an already long sentence is small, possibly zero. This interpretation forms the basis for my conclusion that mandatory minimum sentencing is unlikely to have a material deterrent effect.

The fine payment and Project HOPE experiments also suggest that curve *B*, not curve *A*, more closely resembles what in medical jargon would be described as the dose-response relationship between crime and sentence length. While neither of these studies is directed at the deterrence of criminal behavior, both suggest that, unlike increments in long sentences, increments in short sentences do have a material deterrent effect on a crime-prone population.

Notwithstanding their strengths, these six exemplar studies do not

address several important aspects of the offender response, if any, to the sanction regime. Except for the most trivial offenses, the question at hand is not the deterrent effect of some particular sanction compared to no sanction whatsoever. Instead, it is the deterrent effectiveness of a specified sanction relative to alternative sanction options. In the case of the death penalty, the alternative is a very lengthy prison sentence. For less serious crimes, sanction options to incarceration include fines and various forms of community supervision, or some combination that may also include a period of incarceration. In 2006, for example, 10 percent of felony defendants were diverted to programs such as mandatory drug treatment prior to adjudication. Of those convicted, 29 percent did not receive a jail or prison sentence (Bureau of Justice Statistics 2010) but instead were sentenced to some form of community control, paid a fine, or both.

Theories of deterrence need to be generalized to specify how offenders perceive and respond to the multiplicity of sanction options available for the punishment of most crimes. The theories also need to account for the possibility that offender perceptions of the severity of sanction options may differ. For example, some may view the possibility of life without parole as worse than execution, and still others may view strict community supervision as more onerous than a short period of incarceration (Wood and May 2003). The multiplicity of sanction options and heterogeneity in the response to these options greatly complicate the specification of a deterrence model, but both features are essential to the deterrence phenomenon.

I also note that testing such generalized models of deterrence will require a major expansion of the criminal justice data collection infrastructure at least in the United States. It is currently not possible to measure the availability and frequency of use of sanction alternatives at the state level because the required data are not available. Available data include those from the Bureau of Justice Statistics, which publishes nationwide statistics on sentences for prison admissions and time served for prison releases, based on data collected as part of the National Corrections Reporting Program initiated in the early 1980s. More than 40 states now report annual data on sentences for admissions and time served for releases. Individual-level demographic characteristics are also reported. In principle, these data could be used to measure the administration of the legally authorized dimensions of most state sanction regimes by type of crime. The difficulty is that the

data are often extremely incomplete. In some years, some states fail to report any data, and the data that are sent to the bureau are often so incomplete that it is impossible to construct valid state-level measures of the administration of the sanction regime.

V. Police and Crime

The police may prevent crime through many possible mechanisms. Apprehension of active offenders is a necessary first step for their conviction and punishment. If the sanction involves imprisonment, crime may be prevented by the incapacitation of the apprehended offender. The apprehension of active offenders may also deter would-be criminals by increasing their perception of the risk of apprehension. Many police tactics, such as rapid response to calls for service at crime scenes or postcrime investigation, are intended not only to capture the offender but to deter others by projecting a tangible threat of apprehension. Police may, however, deter without actually apprehending criminals: their very presence may deter a motivated offender from carrying out a contemplated criminal act.

Research on the deterrent effect of police has evolved in two distinct literatures. One has focused on the deterrent effect of the level of police numbers or resources, for example, by examining the relationship between police per capita and crime rates. The other has focused on the crime prevention effectiveness of different strategies for deploying police.

A. Studies of Levels of Police Numbers and Resources

Studies of the effect of police numbers and resources come in two forms. One is an analogue of the imprisonment rate and crime rate studies described in the preceding section. These studies are based on panel data sets, usually of US cities over the period circa 1970–2000. They relate crime rates to the resources committed to policing as measured by police per capita or police expenditures per capita. The second form of study is more targeted. These studies analyze the effect on crime from abrupt changes in the level of policing due, for example, to terror alerts.

1. *Panel Studies.* Panel studies include Marvell and Moody (1994), Levitt (1997, 2002), McCrary (2002), and Evans and Owens (2007). With the exception of McCrary's study, these studies consistently find

evidence that larger resource commitments to policing are associated with lower crime rates.[8]

The studies use different statistical strategies for estimating the effect of police resource levels on crime. For example, Marvell and Moody (1996) analyze two panel data sets and apply Granger-causality type statistical models to these data. Levitt (1997, 2002) uses IV-type regression models. In Levitt (1997), election cycles are used as an IV to untangle the cause-effect relationship between crime rates and police manpower. Levitt (2002) uses the number of firefighters and civil service workers as IVs for the same purpose.

The panel studies consistently find evidence that higher levels of police resources are associated with lower crime rates. Durlauf and Nagin (2011*a*, 2011*b*) discuss important qualifications to the interpretation and validity of this form of analysis. One is that the police panel studies, like the studies of imprisonment and crime, do not distinguish between incapacitation and deterrent effects. The negative associations between police numbers and crime rates identified in these studies may reflect increased effectiveness in apprehending and incarcerating active offenders rather than in deterring crime. More importantly, an underappreciated limitation of these analyses is the assumption that the effect of police levels on crime rates is the same across place and time. As the discussion of studies of the effects of police deployment strategies on crime makes clear, this assumption is not tenable. Nevertheless, the findings of these studies are consistent with those of studies of abrupt changes in police presence that police numbers do matter.

2. *Abrupt Change Studies.* Studies of this type, which are sometimes called "interrupted time series" or "regression discontinuity" studies, examine the effects of abrupt changes in police presence. If the change in police presence is attributable to an event unrelated to the crime rate, studies of this type can provide particularly convincing evidence of deterrence. For example, in September 1944, German soldiers occupying Denmark arrested the entire Danish police force. According to an account by Andenaes (1974), crime rates rose immediately but not uniformly. The frequency of street crimes such as robbery, whose

[8] McCrary identified an error in the computation of standard errors in Levitt (1997) that when corrected nullified the finding of a crime prevention effect of police numbers. Levitt (2002) argues that McCrary's findings do not overturn his general claim that increased numbers of police reduce crime rates and presents new evidence to that effect.

control depends heavily on visible police presence, rose sharply. By contrast, crimes such as fraud were less affected. See Sherman and Eck (2002) and Sherman (in this volume) for other examples of crime increases following a collapse of police presence.

The Andenaes anecdote illustrates several important points. It provides a useful reminder of the difference between absolute and marginal deterrence. As shown in figure 3, absolute deterrence refers to the difference in the crime rate between the status quo level of sanction threat, S_1, and a complete (or near) absence of sanction threat, S_0. The Andenaes anecdote is a compelling demonstration that the absolute deterrent effect is large. However, from a policy perspective, the issue is not the absolute deterrent effect posed by police presence. The question is whether, on the margin, crime can be prevented by incremental increases in police numbers or by changes in the way police are deployed. Also, the anecdote is another useful reminder that deterrent effects are heterogeneous: sanction threats (or the absence thereof) do not uniformly affect all types of crime or, more generally, all types of people.

Contemporary tests of the police-crime relationship based on abrupt decreases in police presence investigate the effect on the crime rate of reductions in police presence and productivity as a result of large budget cuts or lawsuits following racial profiling scandals. Such studies have examined the Cincinnati Police Department (Shi 2009), the New Jersey State Police (Heaton 2010), and the Oregon State Police (DeAngelo and Hansen 2008). Each concludes that decreases in police presence and activity substantially increase crime. Shi (2009) studies the fallout from an incident in Cincinnati in which a white police officer shot and killed an unarmed African American suspect. The incident was followed by 3 days of rioting, heavy media attention, the filing of a class action lawsuit, a federal civil rights investigation, and the indictment of the officer in question. These events created an unofficial incentive for officers from the Cincinnati Police Department to curtail their use of arrest for misdemeanor crimes, especially in communities with higher proportional representation of African Americans, out of concern for allegations of racial profiling. Shi finds measurable declines in police productivity in the aftermath of the riot and also documents a substantial increase in criminal activity. The estimated elasticities of crime to policing based on her approach were -0.5 for violent crime and -0.3 for property crime.

The ongoing threat of terrorism has also provided a number of unique opportunities to study the effect of police resource allocation in cities around the world, including the District of Columbia (Klick and Tabarrok 2005), Buenos Aires (Di Tella and Schargrodsky 2004), Stockholm (Poutvaara and Priks 2006), and London (Draca, Machin, and Witt 2008). The Klick and Tabarrok (2005) study examines the effect on crime of the color-coded alert system devised by the US Department of Homeland Security in the aftermath of the September 11, 2001, terrorist attack. Its purpose was to signal federal, state, and local law enforcement agencies to occasions when it might be prudent to divert resources to sensitive locations. Klick and Tabarrok use daily police reports of crime collected by the district's Metropolitan Police Department for the period March 2002 to July 2003, when the terrorism alert level rose from "elevated" (yellow) to "high" (orange) and back down to "elevated" on four occasions. During high alerts, anecdotal evidence suggested that police presence increased by 50 percent. The authors estimate that each 1 percent increase in number of police during the terror alert reduced total crime by 0.3 percent.

To summarize, studies of police presence conducted since the mid-1990s consistently find that putting more police officers on the street—either by hiring new officers or by reallocating existing officers to put them on the street in larger numbers or for longer periods of time—has a substantial deterrent effect on serious crime. There is also consistency with respect to the size of the effect. Most estimates reveal that a 10 percent increase in police presence yields a reduction in total crime of about 3 percent. Yet these police manpower studies speak only to the number and allocation of police officers and not to what police officers actually do on the street beyond making arrests.

B. Police Deployment and Crime

Much research has examined the crime prevention effectiveness of alternative strategies for deploying police resources. This research has mostly been conducted by criminologists and sociologists. Among this group of researchers, the preferred research designs are quasi experiments involving before-and-after studies of the effect of targeted interventions as well as true randomized experiments. The discussion that follows draws heavily on two excellent reviews of this research by Weisburd and Eck (2004) and Braga (2008).

For the most part, deployment strategies affect the certainty of pun-

ishment through their effect on the probability of apprehension. One way to increase apprehension risk is to mobilize police in a fashion that increases the probability that an offender is arrested after committing a crime. Strong evidence of a deterrent as opposed to an incapacitation effect resulting from the apprehension of criminals is limited. Studies of the effect of rapid response to calls for service (Kansas City Police Department 1977; Spelman and Brown 1981) do not directly test for deterrence but found no evidence of improved apprehension effectiveness. The reason may be that most calls for service occur well after the crime event, with the result that the perpetrator has fled the scene. Thus, it is doubtful that rapid response materially affects crime. Similarly, apprehension risk is probably not materially affected by improved investigations. Eck concluded that "it is unlikely that improvements in the way investigations are conducted or managed have a dramatic effect on crime or criminal justice" (1992, p. 33). The reason is that most crimes are solved either by the offender being apprehended at the scene or by eyewitness identification of the perpetrator (Greenwood, Chaiken, and Petersilia 1977). Modern forensic methods may ultimately improve the effectiveness of postcrime investigations, but as Braga et al. (2011) note, clearance rates have remained stubbornly stable over the period 1970–2007.

The second source of deterrence from police activities involves averting crime in the first place. In this circumstance, there is no apprehension because there was no offense. In my view, this is the primary source of deterrence from the presence of police. Thus, measures of apprehension risk based only on enforcement actions and crimes that actually occur, such as arrests per reported crime, are not valid measures of the apprehension risk represented by criminal opportunities not acted on because the risk was deemed too high (Cook 1979).

One example of a police deployment strategy for which there is good evidence of effectiveness is "hot spots" policing. The idea of hot spots policing stems from a striking empirical regularity uncovered by Sherman and colleagues. Sherman, Gartin, and Buerger (1989) found that only 3 percent of addresses and intersections ("places," as they were called) in Minneapolis produced 50 percent of all calls to the police. Weisburd and Green (1995) found that 20 percent of all disorder crime and 14 percent of crimes against persons in Jersey City, New Jersey, arose from 56 drug-related crime hot spots. Twenty-five years later in a study of Seattle, Weisburd et al. (2004) reported that between 4 and

5 percent of street segments in the city accounted for 50 percent of crime incidents for each year over a 14-year period. Other, more recent studies finding comparable crime concentrations include Brantingham and Brantingham (1999), Eck, Gersh, and Taylor (2000), and Roncek (2000).

The rationale for concentrating police in crime hot spots is to create a prohibitively high risk of apprehension. The first test of the efficacy of concentrating police resources on crime hot spots was conducted by Sherman and Weisburd (1995). In this randomized experiment, hot spots in the experimental group were subjected to, on average, a doubling of police patrol intensity compared with hot spots in the control group. Declines in total crime calls ranged from 6 to 13 percent. In another randomized experiment, Weisburd and Green (1995) found that hot spots policing was similarly effective in suppressing drug markets.

Braga's (2008) informative review of hot spots policing summarizes the findings from nine experimental or quasi-experimental evaluations. The studies were conducted in five large US cities and one suburb of Australia. All but two found evidence of significant reductions in crime. Further, no evidence was found of material crime displacement to immediately surrounding locations. On the contrary, some studies found evidence of crime reductions, not increases, in the surrounding locations but a "diffusion of crime-control benefits" to nontargeted locales. Note also that the findings from the previously described econometric studies of focused police actions—for example, in response to terror alert level—buttress the conclusion that the strategic targeting of police resources can be very effective in reducing crime.

Another example of a police deployment strategy for which there is credible evidence of effectiveness, albeit less consistent than for hot spots policing, is problem-oriented policing. One of the most visible instances of problem-oriented policing is Boston's Operation Ceasefire (Kennedy et al. 2001). The objective of the collaborative operation was to prevent intergang gun violence using two deterrence-based strategies. The first strategy was to target enforcement against weapons traffickers who were supplying weapons to Boston's violent youth gangs. The second involved a more novel approach. The youth gangs themselves were assembled by the police on multiple occasions in order to send the message that the law enforcement response to any instance of serious violence would be "pulling every lever" legally available to

punish gang members collectively. This included a salient severity-related dimension: vigorous prosecution for unrelated, nonviolent crimes such as drug dealing. Thus, the aim of Operation Ceasefire was to deter violent crime by increasing the certainty and severity of punishment, but only in targeted circumstances—specifically, if the gang members committed a violent crime.

Since Operation Ceasefire, the strategy of "pulling every lever" has been the centerpiece of field interventions in many large and small US cities including Richmond, Virginia; Chicago; Stockton, California; High Point, North Carolina; and Pittsburgh. See Kennedy (2009), one of the architects of the pulling every lever strategy, for an extended description of these interventions and the philosophy behind them. Independent evaluations have also been conducted of many of these interventions.[9] As part of the Campbell Collaboration review process, Braga and Weisburd (2012) identified 10 studies of pulling levers focused policing strategies that met their criteria of rigor and relevance to be included in the review. Nine of these studies reported statistically significant reductions in crime. They concluded that "pulling levers focused deterrence strategies are associated with an overall statistically-significant, medium-sized crime reduction effect" (p. 7). However, they caution that focused deterrence has yet to be tested with a randomized control trial. Their caution is also shared by others. In Cook's (2012) commentary on the High Point focused deterrence intervention, he observes that initial conclusions of eye-catchingly large effects have been replaced with far more modest assessments of effect sizes and cautions about the generalizability of the results. Reuter and Pollack (2012) wonder whether a successful intervention in a small urban area such as High Point can be replicated in a large city such as Chicago. Ferrier and Ludwig (2011) point out the difficulty in understanding the mechanism that underlies a seemingly successful intervention that pulls many levers. Despite concerns, these interventions illustrate the potential for combining elements of both certainty and severity enhancements to generate a targeted deterrent effect. Additional evaluations of the efficacy of these multipronged strategies should be a high priority, with the proviso that any designs implemented be amenable to rigorous evaluation as emphasized by commentators. For a useful

[9] For Boston, see Cook and Ludwig (2006); for Richmond, see Raphael and Ludwig (2003); for Chicago, see Papachristos, Meares, and Fagan (2007); for Pittsburgh, see Wilson and Chermak (2011); and for High Point, see Corsaro et al. (2012).

discussion of the importance of understanding mechanisms, see Ludwig, Kling, and Mullainathan (2011). The theory behind focused deterrence interventions includes attention to, among other things, deterrence, police legitimacy, informal social control, police/community relations, the provision of social services, and addressing situational factors. Existing evaluations do not address either the contribution (if any) of individual elements or their likely interplay.

C. Summary

The evidence is clear that large changes in police presence do affect crime rates. The change in presence may be the result of an unplanned event, such as a terror alert that triggers a large increase in police officers in public spaces, or it may be a strategic response to a known crime problem, such as in hot spots policing deployments. In either case, crime rates are reduced in places where police presence has been materially increased. While far from definitive, there is no evidence of displacement of crime to places contiguous to the heightened police presence, at least in the short run. Indeed, there is some evidence of crime reductions in the areas immediately surrounding the heightened presence. By contrast, there is no evidence that the rapidity of the response to crime or the thoroughness of the postcrime investigation has a material influence on crime rates. Combined, these two sets of findings suggest that how police are deployed is as important as the number of police deployed in their influence on crime rates.

Notwithstanding these important findings, some additional issues about police presence remain unresolved. The finding from the hot spots policing evaluations that crime is not displaced to adjacent places may not hold up in the long run. The seeming diffusion of crime control benefits may evaporate as offenders become aware that the heightened patrol activity is not present in adjacent places. More fundamentally, the hot spot itself may be displaced to some new location, for example, to a bar that had not previously been a crime hot spot. A longer-term perspective on the effectiveness of hot spots policing is required.

While the evaluations of hot spots policing provide important evidence that police presence can be a deterrent, overall crime control policy cannot be built around such a narrowly formulated tactic. Evaluations of problem-oriented policing suggest police effectiveness in a wider set of circumstances than intensive patrol of high crime micro-

places. However, these evaluations do not reveal the mechanism by which prevention is achieved.

The introduction distinguished two distinct crime prevention functions of the police: their role as apprehension agents following the commission of a crime and their role as sentinels. In their sentinel role the police are acting, in the parlance of Cohen and Felson (1979), as "capable guardians." Capable guardians are persons whose presence discourages a motivated offender from victimizing a criminal opportunity. Capable guardians include persons with no official crime control authority who nonetheless are personally willing to intervene or to summon those with the authority to intervene. The police themselves also serve as capable guardians in their conventional patrol and monitoring functions.

For many reasons the apprehension agent role is the most scrutinized and recognized crime control function of the police. The apprehension agent function has been and continues to be glamorized by television in long-running programs such as *Dragnet* in the 1950s and 1960s, *Hawaii Five-0* in the 1970s, *Hill Street Blues* in the 1980s, *Homicide Life on the Streets* in the 1990s, and *CSI* and *Law and Order* in the present. The apprehension role is also salient because it involves the police response to real victims of sometimes horrendous crimes and the ensuing efforts to bring the perpetrators to justice. From a technocratic perspective, police effectiveness in this role can be measured with statistics like the clearance rate. From a crime control perspective, the apprehension agent function protects public safety by capturing and incapacitating sometimes dangerous and repetitive offenders. However, as yet there is no evidence that the apprehension agent role results in a material deterrent effect. By contrast, the evidence on police presence suggests that in their sentinel role police can have a very large deterrent effect. While the differential deterrent effect of the police in their apprehension and sentinel roles has not been demonstrated, there is sufficient evidence to characterize it as a hypothesis with sufficient empirical support to make it credible.

What then is the explanation for the differential deterrent effectiveness of the sentinel/guardian and apprehension roles of the police? The model of the decision to victimize a criminal opportunity laid out in the introduction, I believe, provides useful perspective on the answer. The model distinguishes two key probabilities: the probability that the opportunity can be successfully completed, P_s, and the probability of

apprehension conditional on the victimization of the target, P_a. In this model, activities that enhance police visibility, such as concentration of police at crime hot spots, affect P_s, whereas actions such as rapid response to calls for service or improved investigation methods affect P_a. The sentinel role of police is distinct from the apprehension role because the latter comes into play only when deterrence has failed and a would-be offender becomes an actual offender. Thus, at one moment police can function as sentinels and in the next as apprehension agents.

The depiction of the decision to victimize a criminal opportunity in figure 1 provides an explanation for the greater deterrent effectiveness of the police in their sentinel role than in their apprehension role. The police in their sentinel role influence P_s and thereby the probability of all four outcome branches. In particular, improved guardianship reduces the probability that the target can be successfully victimized and increases the probability of the three outcomes that represent failure from the offender's perspective. In contrast, improved effectiveness in the apprehension agent role comes into play only after a crime is committed and can affect only the three branches of the tree related to failure. Thus, innovations that make police more effective sentinels will tend to be more influential in the decision process characterized by this model than innovations in apprehension effectiveness.

The model is also useful in clarifying the basis for the effectiveness of situational crime prevention (Clarke 1995), many forms of which can be construed as reducing P_s. Just as police in their sentinel role reduce the attractiveness of a criminal opportunity, situational crime prevention works by affecting all four branches of the tree.

VI. Perceptual Deterrence and Sanction Risk Perceptions Studies

Analyses of perceptual deterrence examine the association between perceptions of sanction risk, whatever their source, and self-reported illegal behavior or intent to engage in illegal behavior. Analyses of sanction risk perceptions examine the relationship of an individual's perceptions with experience (e.g., being arrested as well as factors external to the individual such as statutorily defined penalties). Some studies address both topics, but most emphasize one or the other.

A. Perceptual Deterrence

The perceptual deterrence literature was spawned by a cadre of researchers (Meier and Johnson 1977; Minor 1977; Tittle 1977, 1980; Grasmick and Bryjak 1980) interested in probing the perceptual underpinnings of the deterrence process.

Perceptual deterrence studies have been based on three types of data: cross-sectional survey studies, panel survey studies, and scenario-based studies. In cross-sectional survey studies, individuals are questioned about their perceptions of the certainty and severity of sanctions and about either their prior offending behavior or their future intentions to offend. For example, Grasmick and Bryjak (1980) queried a sample of city residents about their perceptions of the risk of arrest for offenses such as a petty theft, drunk driving, and tax cheating. They also asked respondents whether they thought they would commit any of these acts in the future. In panel survey studies the sample is repeatedly surveyed on risk perceptions and criminal behavior. For example, Paternoster et al. (1982) followed a sample of students through their 3 years in high school and surveyed them on the frequency with which they engaged in various delinquent acts and their perceptions of the risks and consequences of being caught. In scenario-based studies, individuals are questioned about their perception of the risks of committing a crime that is described to them in detail. They are also asked about their own behavior should they find themselves in that situation. Bachman, Paternoster, and Ward (1992), for instance, constructed a scenario describing the circumstances of a date rape. They then surveyed a sample of college males about their perceptions of the risk of the scenario male being arrested for sexual assault and what they themselves would do in the same circumstance.

Perceptional deterrence research has been faulted with some justification on a number of grounds. One is that the sampled populations are typically high school or college students who do not, by and large, engage in serious crime and delinquency. Other concerns are related to the veracity of the data collected. How well can respondents actually calibrate sanction risks? Do the ways in which questions about perceptions of morality and sanction cost are structured prime responses about actual or projected offending? Despite these questions, in my judgment this class of studies has provided enduring contributions to our understanding of deterrence processes.

One contribution is that, with the exception of the early panel stud-

ies, perception studies consistently find that actual or projected offending is negatively related to perceptions of sanction certainty. Findings of a deterrence-like relationship of self-reported offending with perceptions of sanction severity are less consistent. When combined, these two findings provide still further support for the "certainty" principal, but with a proviso that certainty results in a negative but not necessarily draconian consequence. Grasmick and Bryjak (1980) show that when respondents' assessments of the personal costs of the sanction are incorporated into the analysis, perceptions of severity are negatively associated with self-reported behavior.

A second contribution of the perceptual deterrence literature, which may also be its most important, does not involve the evidence it has amassed on deterrence effects per se. Rather it has focused its attention on the links between formal and informal sources of social control. Recognition of this connection predates the perceptual deterrence literature. Zimring and Hawkins (1973) observe that "official *actions* can set off societal *reactions* that may provide potential offenders with more reason to avoid conviction than the officially imposed unpleasantness of punishment" (p. 174; emphasis in original). See also Andenaes (1974), Gibbs (1975), Blumstein and Nagin (1976), and Williams and Hawkins (1986) for this same argument. Perceptual deterrence research has consistently found that individuals who report higher stakes in conventionality are more deterred by perceived risk of public exposure for lawbreaking.

A salient finding in this regard concerns my own research on tax evasion. Enforcement actions by tax authorities are private matters. Criminal prosecutions, however, are the exception to this rule. They necessarily involve public exposure. Thus, from the taxpayer's perspective, civil enforcement actions jeopardize money but not reputation whereas criminal prosecution jeopardizes both. In Klepper and Nagin (1989*a*, 1989*b*), we found that if respondents perceived no risk of criminal prosecution, a majority of respondents reported a material probability of taking advantage of noncompliance opportunities. However, the perception of a nonzero risk of criminal prosecution was sufficient to deter most of the middle-class respondents to the survey. Stated differently, if the tax evasion gamble also involved putting reputation and community standing at risk, the middle-class respondents to the survey were less likely to consider taking the gamble.

While my tax evasion research does not pin down the specific

sources of these costs, other research on the effects of a criminal record on access to legal labor markets suggests a real basis for the fear of stigmatization (Freeman 1991; Bushway 1996). Freeman estimates that a record of incarceration depresses probability of work by 15–30 percent, Waldfogel (1994) estimates that conviction for fraud reduces income by as much as 40 percent, and Bushway (1996) concludes that even an arrest for a minor offense impairs access to legal labor markets, at least in the short run.

The findings from the perceptual deterrence studies directly relate to two of the main themes of this essay. The first concerns the source of the "certainty" effect. In laying out the implications of the model of the decision to victimize a target, it was pointed out that the cost of apprehension appeared in two of the terms on the right-hand side of equation (2). This side of the equation measures the potential cost of offending: the term measuring the cost of apprehension without conviction and the term measuring the cost of apprehension with conviction. Formal and informal sanction costs appeared only in the second of these terms. Stated differently, apprehension cost is incurred regardless of whether a conviction ensues, whereas sanction costs can be incurred only if apprehension is followed by conviction. This structure formalizes the argument of Williams and Hawkins (1986) that what they call "fear of arrest" serves as a greater deterrent than formal sanction cost. It is also consistent with the conclusion of my own research with coauthors Paternoster (Nagin and Paternoster 1993, 1994) and Pogarsky (Nagin and Pogarsky 2001, 2003) that individuals with the greatest stakes in conformity were the most deterred by informal sanction costs.

The fourth branch of figure 3 is the total cost of formal and informal sanctions. The perceptions research combined with the criminal record research suggests that, for people without a criminal record, informal sanction cost makes a large contribution to this total. That contribution may be substantially reduced once an individual has had contact with the criminal justice system and obtains a criminal record. This observation relates back to a point I emphasized in Nagin (1998). If fear of stigma is a key component of the deterrence mechanism, punishment must be a relatively rare event. Just as the stigma of Hester Prynne's scarlet "A" depended on adultery being uncommon in Puritan America, a criminal record cannot be socially and economically isolating if it is commonplace. For that reason, policies that work well in

the short term may erode their effectiveness over the long run if they increase the proportion of the population who are stigmatized.

This observation is also germane to the recommendation that future empirical research and theorizing should take account of whether and how the experience of punishment (which in my view is inappropriately referred to as specific deterrence) affects the response to the threat of punishment, or general deterrence. The experience of punishment may affect general deterrence in two distinct ways. First, it may affect perceptions of sanction risks. Second, it may affect the basic proclivity for offending. Proclivity could be reduced by effective rehabilitation programs or an individual's conclusion that prison is not an experience to be repeated. However, proclivity could also be increased by stigmatization, erosion of human capital during a spell of incarceration, or the social influence of close contact with a mostly crime-prone population. Nagin, Cullen, and Jonson (2009) provide a detailed discussion of this issue.

B. Sanction Risk Perceptions Studies

Studies of sanction risk perception come in three primary forms: surveys of the general public's knowledge of the sanction regime, studies of the effect of apprehension (or nonapprehension) on risk perceptions and subsequent behavior, and scenario-based studies in which respondents are questioned about their perceptions of the risk of apprehension and punishment in specific circumstances.[10]

1. *General Population Surveys.* Apel (2013) identifies only two surveys of the general public's knowledge of the statutory penalties for the types of crime that compose the FBI's crime index (e.g., murder, robbery). Both are dated. A survey of Tucson, Arizona, residents conducted in the 1970s suggests generally good knowledge of the types of sanctions (e.g., fine, prison) available for the punishment of the 14 types of crime surveyed (Williams, Gibbs, and Erickson 1980). Erickson and Gibbs (1979) also find that respondents were reasonably well calibrated on the relative severity of punishments across types of crime (e.g., punishment for robbery is generally more severe than for larceny). However, a 1960s study commissioned by the California Assembly Committee on Criminal Procedure (1968) found that the general

[10] For an exhaustive and thoughtful review, on which this discussion draws heavily, see Apel (2013).

public's knowledge of the statutorily prescribed level of punishment was poor. Only about a quarter of the sample correctly identified the maximum prison sentence available for the punishment of the various crimes included in the survey. However, 62 percent of incarcerated adults correctly identified the maximum. I return to the large difference in knowledge between the incarcerated and not-incarcerated samples below.

There have also been general population surveys of sanction perceptions for two types of crimes—marijuana use and drunk driving—that are far more prevalent in the general population than crimes such as robbery or burglary. The surveys suggest far better, although hardly perfect, knowledge of the legally available sanctions for these two offenses. MacCoun et al. (2009) describe a study by Johnston Lloyd, O'Malley, and Bachman (1981) of student knowledge of punishment for marijuana possession. In states that decriminalized possession between 1976 and 1980, the percentage reporting a possible jail sentence declined from 58 percent to 18 percent. Corresponding changes for students living in states that did not decriminalize were not as large. This finding suggests that for populations in which there is greater need-to-know of sanction risks, knowledge of the risks is better but still crude. For example, MacCoun et al. (2009) also report that knowledge of the maximum penalties for marijuana use was not good. Surveys of knowledge among adults of drunk-driving penalties by Ross (1973) and Grube and Kearney (1983) also suggest greater awareness of the drunk-driving sanctions and available enforcement tools (e.g., Breathalyzers) than corresponding knowledge for street-type crimes.

The Tucson-based survey and more recent surveys by Kleck and colleagues (Kleck et al. 2005; Kleck and Barnes, forthcoming) attempt to assess the accuracy of sanction risk perceptions. Kleck et al. (2005), for example, survey adults residing in 54 large urban counties. For crimes such as homicide and robbery, they correlate respondent estimates of quantities such as arrests per crime and convictions per crime with ratios based on the actual data. They find that the correlation is close to zero.

The results of the surveys by Kleck and colleagues are not surprising on several counts. First, for the reasons elaborated long ago by Beccaria and Bentham and most recently by Wikström et al. (2012) and Apel (2013), most of the general public has no intention of committing the

types of crime surveyed in these studies.[11] Thus, there is no reason for them to be aware of the sanction regime for these types of crime. Consequently, their ignorance of the sanction regime is not informative about whether people who have a potential need-to-know of the sanction regime obtain that knowledge, however crudely, and take it into account in the decision whether or not to offend. Second, the ratios calculated by Kleck and colleagues pertain only to criminal opportunities that have actually been acted on. As first pointed out by Cook (1979), the ratio of arrest per crime is not a valid measure of the risk of apprehension for criminal opportunities that are not acted on. Third, statistics such as arrests per crime are calculated at the county or city level and may be very poor indicators of risk at the specific locations where would-be offenders are plying their trade (Apel 2013).

2. *Studies of the Effect of Experience on Perceptions.* Salient findings of the early panel perceptual deterrence studies include considerable instability in sanction risk perceptions and that nonoffenders and novice offenders have higher sanction risk perceptions than experienced offenders. Paternoster and colleagues (Paternoster et al. 1982; Paternoster 1983) called this an experiential effect whereby delinquent youths learned that sanction risks were lower than initially anticipated.

An important study by Horney and Marshall (1992) of serious offenders finds that subjects who had higher arrest ratios, that is, self-reported arrests to self-reported crime, reported higher risk perception. Since that time a large number of studies have used longitudinal data to analyze whether the effect of success or failure in avoiding apprehension influences sanction risk perceptions. The analytical strategy involves relating experience with success or failure in prior survey waves with perceptions of apprehension risk in later survey waves. Studies of this type by criminologists were prompted by an influential article by Stafford and Warr (1993), who distinguished between two sources of information on sanction risk: one's own experience and the experience of peers. A parallel literature has also appeared in economics based on the concept of "Bayesian updating."

The Bayesian updating model and the arguments of Stafford and Warr are complementary. Bayesian updating formalizes their arguments. The Bayesian updating model is designed to describe the pro-

[11] In the context of the decision model laid out in Sec. I, these are individuals for whom the net reward of committing a crime is negative even without consideration of sanction costs.

cess by which people update their perceptions of a phenomenon of interest on the basis of new information about that phenomenon. In this case, individuals would update their perceptions of sanction risk with new information regarding success or failure of themselves or their peers in avoiding apprehension. The predictions of the model depend on the specifics of its mathematical specification, but models of this type make predictions about the updating process that are intuitively sensible. The models predict that people generally do not entirely abandon prior beliefs as a result of new information. Most commonly, they only incrementally adjust them.[12]

In the case of perception of apprehension risk, this implies that the experience of apprehension will result in an incremental upward shift in risk perception, and experience of what Stafford and Warr (1993) call "apprehension avoidance" will result in an incremental reduction in risk. A second prediction of the Bayesian updating model is that the magnitude of the change will depend on the depth of prior knowledge. Individuals with more prior knowledge will tend to adjust less to new information than individuals with less prior knowledge. In the context of sanction risk perceptions, this implies that individuals with more experience with offending will make smaller adjustments in their risk perceptions based on current experience with apprehension than will individuals with less experience. Both of these predictions are supported by studies of risk perception updating.

Concerning the first prediction, numerous studies find that increases (or decreases) in perceived apprehension risk are associated with failure (success) in avoiding apprehension (Bridges and Stone 1986; Piliavin et al. 1986; Paternoster and Piquero 1995; Pogarsky, Piquero, and Paternoster 2004; Pogarsky, Kim, and Paternoster 2005; Matsueda, Kreager, and Huizinga 2006; Lochner 2007; Hjalmarsson 2008). There are, however, exceptions to this finding. Apospori and Alpert (1993) and Pogarsky and Piquero (2003) report evidence that is the reverse of this prediction. Pogarsky and Piquero attribute this to a variant of what is called the "gambler's fallacy" whereby offenders believe that bad luck is not followed by bad luck. This is an interesting possibility, but the evidence is overwhelmingly consistent with the Bayesian updating model.

[12] Prior history may be ignored if a regime change (e.g., the occupying German army arresting the Danish police force) makes it irrelevant.

Evidence consistent with the second prediction is reported in Pogarsky, Piquero, and Paternoster (2004), Matsueda, Kreager, and Huizinga (2006), and Anwar and Loughran (2011). Anwar and Loughran conducted a particularly thorough test of this prediction. They analyzed a sample composed of about 1,300 adjudicated/convicted youths from Arizona and Pennsylvania enrolled in the Pathways to Desistance study who were interviewed eight times in 5 years (Mulvey 2011). Being arrested significantly increased subjective probabilities (prediction 1), but the magnitude of the change was less for more experienced offenders (prediction 2). Specifically, they showed that experienced offenders placed relatively more weight on their prior subjective probabilities and therefore updated less in response to new arrests. Inexperienced offenders, by contrast, updated more by placing more weight on their current arrest ratios and less weight on their prior subjective probabilities. It is also noteworthy that they concluded that the effect of arrest on subjective probabilities was specific within classes of criminal behaviors: youths arrested for aggressive crimes did not update their subjective probabilities concerning income-generating crimes. This finding implies that there are not spillover effects across classes of crime.

3. *Studies of Situational Effects on Risk Perceptions.* This grouping of studies examines the effect of situational factors on risk perceptions. Particularly important in this regard are situational factors that can be manipulated by policy, such as official sanctions and police presence.

As already noted, knowledge of official sanctions seems to be strongly affected by the need-to-know principle. Knowledge is better, but hardly perfect, among populations with the greatest involvement in the illegal activity. On the basis of the California assembly study, for example, knowledge of maximum penalties for various FBI index-type crimes was far better for incarcerated sample members than for not-incarcerated sample members.

Other interesting evidence of awareness of official sanctions is the previously discussed study by Hjalmarsson (2009) of the effect of reaching the age of majority on perceptions of the risk of incarceration for auto theft. She found that male respondents in the 1997 National Longitudinal Survey of Youth increased that risk by 5.2 percentage points upon reaching their age of majority. The increase, however, had no statistically significant effect on behavior.

Evidence on how police presence affects perceptions of apprehension risk is scant. In my own work with Paternoster, we constructed sce-

narios and examined how respondent perceptions of sanction risks were affected by scenario conditions (Nagin and Paternoster 1993). We found that respondent perceptions of sanction cost in a drunk-driving scenario were higher in the scenario condition involving a police crackdown on drunk driving versus a scenario condition described as involving state police cutbacks. In addition, perceptions of sanction cost were lower if surveillance could be avoided by driving on back roads. In scenarios concerning peer provocation, Wikström et al. (2012) found that adolescents reported a lower likelihood of violent response in scenario conditions in which adult monitors were present. Evidence from ethnographic studies suggests that offenders are very conscious of police presence when selecting targets. Wright and Decker (1994) report that burglars avoid neighborhoods with a heavy police presence and that robbers prefer to target individuals unlikely to report the crime to the police, such as drug dealers.

C. Summary

Perceptual deterrence research has established that self-reported offending or intention to do so is linked to sanction risk perceptions. The outstanding question is whether those perceptions are grounded in reality. If they are not, behavior is beyond the reach of public policy. The evidence on the sources of sanction risk perceptions suggests that risk perceptions are affected by an individual's own experience with success or failure at averting apprehension. The link between perception and the legally authorized sanctions is less compelling but does indicate that there is at least a rough awareness among individuals in a need-to-know scenario. The other key component of the sanction regime is the intensity of application of the legally authorized sanctions. Research on this topic is based on general population studies of the correlations of perceptions of quantities of the ratio of arrest to crimes with estimates of these ratios calculated from official statistics. For reasons discussed above, in my judgment these studies are not informative about whether perceptions of intensity among the population with need-to-know sanction risks are affected by the actual intensity of application of legally authorized sanctions.

Pogarsky (2007) offers a useful taxonomy of responsiveness to legal threats for considering the implications of these summary observations. The taxonomy distinguishes three groups: acute conformists, deterrables, and incorrigibles. In the context of the decision model laid out

in Section I, conformists are individuals for whom reward minus commission cost is negative. For reasons I have already discussed, they have no need to gain knowledge of sanction risks because there is no profit in crime even without potential sanction costs. Deterrables are individuals for whom reward minus commission cost is positive and who are attentive to sanction threats. For such individuals the issue is whether the net benefit of successful commission exceeds the potential costs attending failure. The incorrigible group is also composed of individuals for whom crime is profitable but who for whatever reason are not attentive to sanction threats. The relative sizes of the incorrigible and deterrable groups and the specific form of the sanction regime will determine the effectiveness of criminal justice public policy in preventing crime via deterrence and thereby avoiding the sanction costs of incapacitation.

Future research on sanction risk perceptions needs to target Pogarsky's deterrables and incorrigibles to gain better knowledge of their awareness of the two key elements of the sanction regime: the legally authorized sanctions and the intensity of their application. For the types of crime in the FBI index this will require abandoning surveys of the general population and instead sampling populations with a large representation of deterrables and incorrigibles. An example of such a survey is the Pathways to Desistance project used in the Anwar and Loughran (2011) analysis, which sampled juveniles adjudicated for felony offenses in Philadelphia and Phoenix.

Surveys targeting deterrables and incorrigibles should also include batteries of questions designed to learn how the actions of the police and other guardians affect perceptions of the probability of success, which, for the reasons described in Section V, is likely to be particularly decisive in the deterrence process.

VII. Conclusions

Over the past four decades, much has been learned about the foundations of deterrence that were laid out more than two centuries ago by Cesare Beccaria and Jeremy Bentham. We now know that deterrence is ubiquitous but that the effects are heterogeneous, ranging in size from seemingly null to very large. There is little evidence that increasing already long prison sentences has a material deterrence effect. Evidence on the deterrent effect of the certainty of punishment

is more consistent, but the source of the effect is less clear. In this essay I have argued that the certainty effect stems primarily from police functioning in their official guardian role rather than in their apprehension agent role.

These conclusions have important policy implications that are developed in detail in Durlauf and Nagin (2011*b*). They suggest that lengthy prison sentences cannot be justified on deterrent grounds, but rather must be justified either on crime prevention through incapacitation or on retributive grounds. The crime prevention efficiency of incapacitating aged criminals is dubious, and thus the case for lengthy prison sentences must rest on retributive considerations. The conclusions also suggest that crime control effectiveness would be improved by shifting resources from corrections to policing methods that enhance the effectiveness of police in their official guardian role.

While much progress has been made in understanding sources of deterrence and the circumstances in which deterrence is and is not effective, much remains to be learned. Theory needs to be generalized to combine the response to the threat of punishments, known as general deterrence in criminology, and the response to the experience of punishment, which I have argued is inappropriately labeled specific deterrence. A second theoretical and empirical gap concerns the concept of a sanction regime and its two dimensions: the legal authority for different types of sanctions and the way in which authority is administered. These two dimensions combine to determine the certainty, severity, and celerity of sanction options available for punishment of a specific type of crime. Theories of deterrence, however, specify sanction threats in the singular, not in the plural. Theories of deterrence that conceive of sanctions in the singular do not provide the conceptual basis for considering the differential deterrent effect of different types of sanction options. The empirical companion to this theoretical expansion involves assembling the data required to measure sanction regimes.

A third theoretical and empirical gap involves sanction risk perceptions. Deterrence is the behavioral response to the perception of sanction threats. Establishing the link between risk perceptions and actual sanction regimes is imperative because policy cannot directly manipulate perceptions. Unless perceptions adjust, however crudely, to changes in the sanction regime, the desired deterrent effect will not be achieved. More research on the sources of sanction risk perceptions in

crime-prone populations is likely to pay large dividends for theory and policy.

The fourth major gap in theory and empirical knowledge involves a thorough testing of my contention that the guardian role, not the apprehension role, of the police is the most important source of their effectiveness in crime prevention. This theory also needs to be expanded to account for how the police and other guardians affect the distribution of criminal opportunities.

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Exhibit O

Journal of Economic Psychology 47 (2015) 1–16

Contents lists available at ScienceDirect

Journal of Economic Psychology

journal homepage: www.elsevier.com/locate/joep

Review

Like ripples on a pond: Behavioral spillovers and their implications for research and policy

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ARTICLE INFO

Article history:
Received 30 March 2014
Received in revised form 15 December 2014
Accepted 18 December 2014
Available online 5 January 2015

JEL classification:
C18
C91
C93
D03

PsycINFO classification:
2260
2346
2360
3040

Keywords:
Behavioral spillovers
Policy-making
Nudges
Crowding in/out

ABSTRACT

No behavior sits in a vacuum, and one behavior can greatly affect what happens next. We propose a conceptual frame within which a broad range of behavioral spillovers can be accounted for when applying behavioral science to policy challenges. We consider behaviors which take place sequentially and are linked, at a conscious or unconscious level, by some underlying motive. The first behavior leads to another behavior which can either work in the same direction as the first (*promoting* spillover), or push back against it (*permitting* or *purging* spillover). Looking through this conceptual lens at the existing evidence, we find pervasive evidence for all kinds of spillover effects across a variety of fields and domains. As a result, behavioral scientists, especially those seeking to inform policy, should try to capture all the ripples from one behavior to the next when a pebble of intervention is thrown in the pond, and not just at the immediate behavioral splash it makes.

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http://dx.doi.org/10.1016/j.joep.2014.12.003
0167-4870/

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1. Introduction

Policymakers have begun taking seriously the results of behavioral research (Camerer, 1999; Camerer, Issacharoff, Loewenstein, O'Donoghue, & Rabin, 2003; Congdon, Kling, & Mullainathan, 2011; Dolan et al., 2011; Shafir, 2012; Sunstein, 2011; Thaler & Sunstein, 2003). This trend is to be welcomed but the various discussions of the evidence are typically made in 'behavioral silos', focusing on one specific behavioral response at a time (Thøgersen, 1999a). Yet no behavior sits in a vacuum and we need to consider the possible spillover effects from one behavioral response to the next.

Imagine an intervention that successfully reduces energy consumption in the home, e.g. by installing LED light bulbs, but that has the spillover effect of increasing energy use elsewhere, e.g. through leaving more lights on at work. Some or all of the benefits from the reduction in CO_2 emissions could be lost (Gillingham, Kotchen, Rapson, & Wagner, 2013; Jacobsen, Kotchen, & Vandenbergh, 2012; Thøgersen & Crompton, 2009; Tiefenbeck, Staake, Roth, & Sachs, 2013). To inform policy, we should ideally capture all ripples of behavior when a pebble of intervention is thrown in the pond. The '*mapping of these ripples is now one of the most exciting pursuits in psychological research*' (Kahneman, 2011, p.53).

2. Behavioral spillovers

We propose a conceptual frame within which a broad range of 'behavioral spillovers' (Thøgersen, 1999a) can be systematically interpreted when applying behavioral science to policy challenges. Our framework is based on three building blocks.

First, we begin by assuming that two *different* behaviors take place sequentially: *behavior 1* is followed by *behavior 2*. This differentiates the analysis of behavioral spillovers from the long-established, distinct, literature on *adaptive learning*, which typically focuses on the repetition of the *same* behavior over time (e.g. learning in repeated games, as opposed to playing one-shot games, Fudenberg & Levine, 1998; Goeree & Holt, 2001; Vega-Redondo, 1996).

The typical situation we have in mind is a sequence of two different behaviors where *behavior 1* is the target of an intervention. An intervention is defined broadly here: it could be a policy intervention by a public decision-maker, or an experimental manipulation by a researcher. Implicitly, the following discussion is conducted on the presumption that we can compare a 'treatment' case where *behavior 1* is targeted by an intervention with a 'control' group where there is no intervention. What we would like to emphasize, however, is that the key focus of our interest here is what happens to *behavior 2* as the consequence of the intervention.

It is not uncommon, in fact, to find studies in the economics and psychology literatures where it is looked at when and how a policy intervention could '*backfire*' in the sense of having unintended compensatory or offsetting effects with respect to the ones originally envisaged by the decision-maker (e.g. Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007). For instance, for interventions in the context of risk and safety (e.g. seat belts in cars), the theories of *risk compensation*, *risk homeostasis*, or *behavioral adaptation* have since long argued that people can adjust their behavior in response to the perceived level of risk (Asch, Levy, Shea, & Bodenhorn, 1991; Bhattacharyya & Layton, 1979; Cohen & Einav, 2003; Evans & Graham, 1991; Garbacz, 1990a, 1990b, 1991, 1992; Peltzman, 1975; Rudin-Brown & Jamson, 2013; Schoemaker, 1993; Viscusi & Cavallo, 1994; Wilde, 1982a, 1982b, 1998; Wilde, Robertson, & Pless, 2002). This is an interesting but distinct question, the difference with our focus here being that those analyses typically look at the impact of the intervention on the *same* behavior originally targeted, not at what happens to *another* behavior occurring later on.

To narrow further down the scope of our analysis, we exclude from our remit two types of 'interventions' that deserve separate investigation. The first one refers to all those situations where *behavior 1* is not conceptually distinguishable from the intervention itself. Some archetypical examples of these situations refer to the literature on *priming* (Bargh, 1990; Gollwitzer, Heckhausen, & Steller, 1990). Priming occurs unconsciously when '*the passive activation of trait categories in one situational context carried over to influence social judgments in subsequent, ostensibly unrelated contexts*' (Bargh, 2006, p.148). Among the many examples, more self-sufficient behavior was prompted by the mere presence of a pile of Monopoly notes or a screensaver with various denominations of currency (Vohs, Mead, & Goode, 2006), whereas more cooperative, or competitive, behavior was prompted by the mere presence of a backpack, or a briefcase, respectively (Kay, Wheeler, Bargh, & Ross, 2004). As another 'ideomotor' example, subjects shown pictures of a library spoke more quietly thereafter than subjects shown pictures of a railway station (Aarts & Dijksterhuis, 2003).

While in all these priming situations, the intervention clearly affects a subsequent behavior, it is also clear that '*behavior 1*' consists of the mere exposure to the priming manipulation itself which, more often than not, is a subliminal presentation of words or images. In other words, rather than a triplet '*intervention – behavior 1 – behavior 2*' most priming situations consist of a manipulation and *a single* behavior.

The second area excluded from our analysis pertains to *price mechanisms* and financial incentives. For instance, the overall use of energy can increase in response to an environmental policy intervention that results in lower costs of the energy. We

do not see this effect as a 'behavioral spillover', though: it is merely a market adjustment to a relative price change, similarly to many other 'rebound' effects commonly referred to as '*Jevons paradoxes*' (Alcott, 2005; Jevons, 1866).

Analogously, the economic and psychology literature on *financial incentives* has since long highlighted the '*hidden costs*' of incentives (Fehr & List, 2004), including crowding out of intrinsic motivation (Deci, Koestner, & Ryan, 1999; Frey & Oberholzer-Gee, 1997); changing social norms or individual beliefs about social norms (Gneezy & Rustichini, 2000a, 2000b; Heyman & Ariely, 2004); interacting in unpredictable ways with reciprocity, reputation, and social comparison concerns (Ariely, Bracha, & Meier, 2009; Dur, Non, & Roelfsema, 2010; Fehr & Gachter, 1997; Gachter & Thoni, 2010; Greiner, Ockenfels, & Werner, 2011; Rigdon, 2009); and 'choking' due to the anxiety aroused by relating payment to performance (Ariely, Gneezy, Loewenstein, & Mazar, 2009). In such cases, incentives may '*backfire*', in that they result in the opposite effects to the ones originally envisaged (Bénabou & Tirole, 2003, 2006; Fehr & Falk, 2002; Kamenica, 2012). The focus of such 'unintended consequences' of financial incentives, however, has mainly been on the *same* behavior originally targeted by the incentive. With few exceptions (e.g. Al-Ubaydli, Andersen, Gneezy, & List, in press; Dolan & Galizzi, 2014), this stream of literature has not looked at the spillover effects that incentives may have on behaviors *other* than the one directly targeted. For the same reasons highlighted above about the studies on risk compensation and price adjustments, we thus exclude the literature on financial incentives from our analysis, and reiterate that our core interest here is on what happens to *behavior 2* after the intervention.

The second building block of our conceptual framework is that we assume that the two subsequent behaviors are linked, at a conscious or unconscious level, by some underlying *motive*. With motives here we mean a broadly intended range of factors that drive behavior (Bargh & Barndollar, 1996). When behaviors occur under conscious deliberation and individuals are fully aware of their *preferences*, the motive can be represented as the argument of a standard utility function, as typically postulated in traditional economics models.

More generally, motives can also be conceptualized as *deep preferences*, '*self-defining*' or '*identity goals*' (Wicklund & Gollwitzer, 1981, 1982), or '*long-term goals, major affiliations, and basic values*' (Baumeister, 1986): individuals may at times be uncertain over these motives, may not consciously attend to them, or may even be unaware of them, because, for instance, of imperfect recall, or because distracted by other more salient or tempting options (Aarts & Dijksterhuis, 2000; Akerlof & Kranton, 2000; Bargh & Barndollar, 1996; Bargh, Gollwitzer, Lee-Chai, Barndollar, & Trotschel, 2001; Bénabou & Tirole, 2006, 2011; Chartrand & Bargh, 1996; DellaVigna, 2009; Dijksterhuis & Bargh, 2001; Dijksterhuis, Bos, Nordgren, & van Baaren, 2006; Dijksterhuis & Nordgren, 2006; Gneezy, Gneezy, Riener, & Nelson, 2012; Gneezy, Imas, Brown, Nelson, & Norton, 2012; Gollwitzer, 1990; Kahneman, 2003; Kruglanski et al., 2002; Norton, 2012; Novemsky & Dhar, 2005; Trope & Fishbach, 2000).

To visualize this most general case, what we have in mind is an analytical framework such as the prominent '*Beliefs As Assets*' model for moral behavior by Bénabou and Tirole (2011), to which we refer for a full theoretical analysis. For the sake of illustration only, we report here a simplified variant of the Bénabou and Tirole (2011) model inspired to the '*general satisfaction*' idea by Frijters (2000) and Van Praag, Frijters, and Ferrer-i-Carbonell (2003), and to its extension in terms of the *Adaptive Global Utility Model* (*AGUM*) by Bradford and Dolan (2010).

In our setting, we imagine that an individual derives satisfaction from $k = 1,\ldots,K$ primitive life-satisfaction 'accounts': for instance, wealth, health, career, family, morality, friendship, pleasure, purpose, political engagement, the environment, and so on. In this setting, *motives* correspond to those life satisfaction accounts, the '*deep preferences*' driving individual choices and actions. The multiplicity of motives reflects the fact that, in reality, we may hold different, possibly conflicting, identity goals simultaneously (Baumeister & Vohs, 2007; Carver, 2003; Carver & Scheier, 1998; Dhar & Simonson, 1999; Fishbach & Dhar, 2005; Kruglanski et al., 2002; Louro, Pieters, & Zeelenberg, 2007; Simon, 1967; Stroebe, Mensink, Aarts, Schut, & Kruglanski, 2008; Susewind & Hoelzl, 2014), and corresponds to the case of '*multidimentional identity*' in Bénabou and Tirole (2011).

We next imagine that X^N represents the space of all possible *behavioral outcomes*. For instance, think at an outcome as a consumption bundle, an allocation of money across different destinations, or a distribution of time or effort among different activities. A specific behavioral outcome $x_i \in X^N$ is thus an observable metrics: the amount of money spent in a luxury good or donated to a charity; the hours in a day spent working, exercising, or volunteering; the number of CO_2 emissions. Individuals are assumed to have a, conscious or unconscious, single preference relation, $\succcurlyeq$, which supports a one-dimensional ranking across all pair-wise comparisons of possible outcomes $(x_i, x_j) \in X^N$ where (x_i, x_j) represent N-dimensional vectors of specific points in the overall behavioral outcomes space X^N.

What is more, we assume that there exists a *profile* of preference relations

$$P \equiv (\succcurlyeq_1, \succcurlyeq_2, \ldots, \succcurlyeq_k) \tag{1}$$

which maps the possible outcomes $(x_i, x_j) \in X^N$ onto rankings defined over each of the $k = 1,\ldots,K$ primitive life-satisfaction 'accounts' for a specific individual. Thus, for instance, one behavioral outcome can be preferred to an alternative over a motive (e.g. pleasure, career) but not over another one (e.g. health, family).

As in the *AGUM* model, one can visualize each preference relation using functional relationships $v^k(x_i) : X^N \to R^+, \quad \forall\, k = 1, \ldots, k$, such that $v^k(x_i) \succcurlyeq v^k(x_j)$ if and only if $x_i \succcurlyeq_k x_j$. These functions can be rationalized as value functions of the *direct* satisfaction from a behavioral outcome for each of the $k = 1,\ldots,K$ primitive accounts, such that the single vector of outcomes x_i simultaneously generates K measures of direct life satisfaction. This reflects the idea that the same behavior or mean can serve more than one identity goal ('*multifinality*' in Shah, Friedman, and Kruglanski (2002)).

Importantly, besides direct satisfaction from a behavioral outcome, each motive's life satisfaction also includes indirect utility from *self-perception* or *self-image* $I^k(\cdot)$ over that same account. This reflects the idea that we may derive satisfaction not just from tangible behavioral outcomes, but also from the accumulation of signals and beliefs about our own identities (Bénabou & Tirole, 2011; Gomez-Minambres, 2012; Mazar, Amir, & Ariely, 2008; Nisan & Horenczyk, 1990; Tesser, 1988; Wicklund & Gollwitzer, 1981). For instance, in the prominent context of donations, one can derive direct utility from contributing to a public good ('*pure altruism*') but also indirectly from feeling good about the act of giving itself (e.g. the '*warm-glow*' in Andreoni (1990)). In line with the '*self-inference*' process described by Bénabou and Tirole (2011), in fact, individuals derive indirect satisfaction from signals because they may have no conscious access to their deep preferences, or because they recall their true motives and identities only imperfectly. The indirect satisfaction from self-image signals, moreover, is a key channel through which the various self-regulation mechanisms based on entitlement and justification take place (De Witt Huberts, Evers, & De Ridder, 2014; Hsee, 1995; Kivetz & Simonson, 2002; Kivetz & Zheng, 2006; Merritt, Effron, & Monin, 2010; Mukhopadhyay & Johar, 2009).

Alike in Bénabou and Tirole (2011) we imagine that the accumulation of *self-image* follows a dynamic process, where the levels of $I^k(\cdot)$ at $t = 2$ typically depends on the outcomes of behavior 1 and on the initial level of self-image in that account, that is: $I^k_{t=2} = I^k(x^k_{t=1}; I^k_{t=1})$ where $t = 1, 2$ refers to the time when behavior 1 and 2 take place respectively. This reflects the idea that self-beliefs are, to some extent, '*malleable through actions*' (Bénabou & Tirole, 2011). In what follows we assume that there are no links between self-images across different motives (e.g. '*being healthy*' and '*being green*'), but we will return to this point in Section 7.

We further imagine that the account value functions can be combined into an ultimate '*global life-satisfaction*' function as in Frijters (2000) and Van Praag et al. (2003). Alike in the *AGUM* model, one way to do it is by attaching increasing and quasi-concave weights $\omega_k(\cdot)$ to each particular life account, and, for instance, taking a linear generalized utilitarian form for the global satisfaction such as

$$U(x) = \sum_k \omega_k(\cdot) V(v^k(x), I^k(\cdot)) \tag{2}$$

The weight attached, consciously or unconsciously, to a specific life satisfaction account reflects the facts that the value of a given motive can be known only at a subconscious level (Bodner & Prelec, 2003; Fishbach, Friedman, & Kruglanski, 2003; Simon, 1967), and that at times people may even be unaware of the existence of some accounts (e.g. one may be unaware of career or family motives before getting a job, or meeting the significant other, respectively). This also reflects the idea of '*multidimentional identity*' in Bénabou and Tirole (2011), where people tradeoff between different dimensions of identity '*linked by uncertainty over their relative value*' (p.815). Equivalently, the weights attached to each life satisfaction account can be interpreted in terms of *attention* (Chabris & Simons, 2011; Dolan, 2014; Kahneman, 1973; Moskowitz, 2002), or as indicators of the cognitive '*accessibility*' of each specific construct: the higher is the weight, the more accessible is the motive (Forster, Liberman, & Higgins, 2005; Goschke & Kuhl, 1993; Higgins & King, 1981; Kruglanski, 1996; Kruglanski & Webster, 1996; Shah & Kruglanski, 2002, 2003; Srull & Wyer, 1979; Zeigarnik, 1927).

Finally, alike in the *AGUM* model, we imagine that the weights attached to each account can also change over time following a dynamic process similar to the one imagined for the self-images. In particular, the weight of motive k at time $t = 2$, $\omega_k(\cdot)$ typically depends on the initial level of the weight at $t = 1$, and on the outcomes of behavior 1, that is $\omega^k_{t=2} = \omega^k(x^k_{t=1}; \omega^k_{t=1})$ where $t = 1, 2$ refers to the time when behavior 1 and 2 take place respectively. Here too we imagine that there are no cross-motives effects on the weights. Such a dynamics of weights readjustment does not necessarily need to be conscious or deliberate, though. Weights attached to different motives can shift as result of an unconscious reprioritization process where an unattended goal 'demands' a higher priority by '*intruding on awareness*' (Carver, 2003; Simon, 1967). For instance, not only intrusive thoughts, rumination, and dreams, but also moods, affects, and emotions can often manifest themselves as calls for reprioritizing weights across identity motives (Carver, 2003; Forster et al., 2005; Fredrickson, 1998; Isen, 1987, 2000; Isen & Simmonds, 1978; Lewin, 1951; Martin & Tesser, 1996; Simon, 1967; Tesser, Crepaz, Collins, Cornell, & Beach, 2000; Trope & Neter, 1994; Trope & Pomerantz, 1998).

In our setting, thus, having a high *motive* is the amalgamation of three main factors: enjoying direct satisfaction from the behavioral outcome ('*I have just donated £10 to a good cause*'); benefitting from the associated self-inference ('*I am a good person*'); and, consciously or unconsciously, attaching a high weight to that motive in terms of life satisfaction ('*Being a good person makes me happy*').

This conceptualization of the motives naturally lends itself to introduce the last building block of our framework, the link between behavior 1 and 2. In our framework, in fact, the first behavior leads to a subsequent behavior which, as the motive is concerned, can either work in the same direction as the first, or push back against it.

Consider the initial motive to reduce CO_2 emissions by cycling or car-sharing to work (Evans et al., 2013). This could lead to another behavior which also reduces emissions, e.g. by using the train instead of the airplane for domestic travel. We refer to this sequence of behaviors with concordant sign as a *promoting* spillover: the initial push to the motive promotes a further increase later on.

The same first behavior, however, might instead lead to another behavior which increases emissions, e.g. using the car more with our family. We refer to this as a *permitting* spillover: the initially increased motive permits a subsequent disengagement from the same. There is then a final class of spillovers, which we call *purging*, where the second behavior is motivated out of a, conscious or unconscious, desire to undo some of the damage caused by the first behavior. For example, we

might use the train for holidays in response to using long-haul flights for work, so that the 'environmental' motive is first undermined and then restored.

In practice, the sequence of concordant or discordant signs can be visualized referring to the observable *behavioral outcome*, while the motive's *self-image* and *weight* mainly illustrate the mechanisms linking the two behaviors. Consider these further examples.

Wearing a charity's pin today (*behavior 1*) can have a number of effects on tomorrow's charitable giving (*behavior 2*). On the one hand, it can highlight an underlying 'pro-sociality' motive of which we were previously unsure or even unaware, leading us to attach a higher weight to that account tomorrow. This more accessible motive, in turn, may lead us to deliberately maximize the direct utility from donating to a charity tomorrow, thus triggering a *promoting* behavioral spillover. Similarly, signing at the top of a tax return form before filling it out, can lead to unconsciously highlight a previously unattended 'morality' account, with the result of cheating less in the subsequent tax declaration (Shu, Mazar, Gino, Ariely, & Bazerman, 2012).

On the other hand, if the 'pro-sociality' motive has already some positive weight attached to it, today's wearing of the charity's pin can boost our self-image of 'being a do-gooder'. In turn, this can lead to *permitting* spillovers through two channels. If the utility from self-image is a, perfect or imperfect, substitute for the direct satisfaction from donating money, we can end up donating *less* to a charity tomorrow. Alternatively, or concurrently, having already accomplished, or attended to, the 'pro-sociality' motive today means that resources can be, consciously or unconsciously, redirected toward other accounts tomorrow, with a consequent reprioritization of weights that also leads to donate *less* to the charity tomorrow.

On the other hand, a small lie today when claiming a welfare benefit (*behavior 1*) can have various effects on tomorrow's 'moral' behavior (*behavior 2*). For instance, as long as the 'morality' motive is already accessible, today's lying can depress our self-image of 'being a good person'. In turn, this can lead to *purging* spillovers through two channels. If the disutility from a depressed self-image is a, perfect or imperfect, substitute for the direct satisfaction from paying taxes, we can cheat *less* in our tax declaration tomorrow in order to restore our satisfaction in that account. Alternatively, or concurrently, depressed self-image leads to a weight reprioritization that increases the accessibility of the 'morality' motive tomorrow. This heightened accessibility, in turn, may also lead us to cheat *less* in our tax declaration tomorrow.

Finally, one can also imagine cases of *all-negative promoting* spillovers. For instance, lying to claim a welfare benefit today can compress or temporarily 'shut down' the underlying 'morality' motive, leading us to no longer attach any weight to that account of life satisfaction tomorrow. This reduced accessibility, in turn, may lead us to cheat *more* in the tax declaration tomorrow under the presumption that our moral identity 'has already gone', thus triggering a 'downward spiral' all-negative promoting spillover.

Fig. 1 illustrates some further possible examples of promoting, permitting, and purging spillovers in the context of *health* behavior.

Our tri-partition of behavioral spillovers is thus in line with the well-established distinctions in psychology between *consistency* (assimilation) and *contrast* (compensatory) behavior (Bargh et al., 2001; Bem, 1972; Cialdini, Trost, & Newsom, 1995; Conway & Peetz, 2012; Cooper & Fazio, 1984; Dijksterhuis & Bargh, 2001; Dijksterhuis et al., 1998; Festinger, 1957; Gneezy, Imas et al., 2012; Liberman, Forster, & Higgins, 2007; Mussweiler, 2003; Norton, 2012; Schwarz & Bless, 2005); and between *reinforcing* (highlighting) and *compensating* (balancing) self-regulatory dynamics (Baumeister, Heatherton, & Tice, 1994; Carver, 2003; Carver & Scheier, 1981, 1998; Dhar & Simonson, 1999; Fishbach & Choi, 2012; Fishbach & Dhar, 2005; Fishbach, Koo, & Finkelstein, in press; Fishbach & Zhang, 2008; Fishbach, Zhang, & Koo, 2009). In economics, our tri-partition echoes the distinctions between motivation *crowding-in* and *crowding-out*; *complement* and *substitution* effects; and *positive* and *negative externalities* (Bénabou & Tirole, 2003, 2006; Frey & Oberholzer-Gee, 1997; Gneezy & Rustichini, 2000a, 2000b).

Also, our tri-partition openly reckons that, when it comes to compensatory or contrast behavior, the order of discordant signs really matters (Forster, Grant, Idson, & Higgins, 2001; Truelove, Carrico, Weber, Raimi, & Vandenbergh, 2014). The psychological drivers beyond *permitting* and *purging* spillovers, in fact, are conceptually and practically very distinct. The permitting versus purging distinction, for instance, is closely in line with '*self-completion theory*' (Wicklund & Gollwitzer, 1981, 1982), which postulates that, upon achieving an identity-relevant goal, we can feel 'complete' and thus 'temper' our future identity goal strivings. Conversely, upon experiencing a failure in pursuing an identity goal, we can feel 'incomplete' and step up our goal striving. The distinction is also in line with the closely connected '*cybernetic control*', '*feedback-loop*', or '*cruise control*' model (Carver, 2003; Carver & Scheier, 1981, 1982, 1990, 1998): while after feeling a failure we

		Behavior 2	
		Eat healthy	Eat Less Healthy
Behavior 1	A run after work	**Promoting**	**Permitting**
		I ran an hour, let's keep up the good work	*I ran an hour, I deserve a big slice of cake*
	Sofa-sitting after work	**Purging**	**Promoting**
		I've been lazy today, best not eat so much tonight	*I've been lazy today, so what the heck, let's have a big slice of cake*

Fig. 1. Examples of promoting, permitting, and purging behavioral spillovers in health behavior.

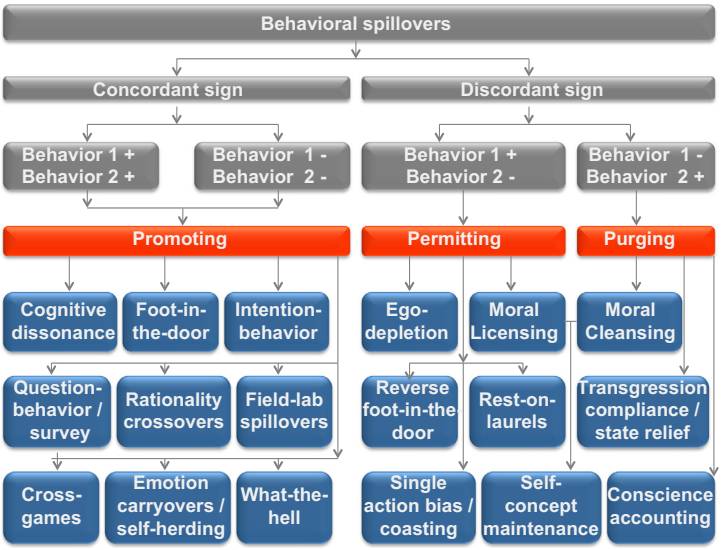

Fig. 2. Main types of promoting, permitting, and purging behavioral spillovers documented in the behavioral science literatures.

typically try harder in an attempt to catch up, after experiencing a progress in excess of our envisaged target we are likely to '*coast*' a little, '*not necessarily stop, but ease back*' (Carver, 2003, p. 246). In our setting, this temporary 'pull back' dynamics is one of the mechanisms explaining how 'freed up' resources can lead to reprioritize weights across motives.

All the above conceptualizations in psychology and economics have insofar proceeded along parallel streams, and our framework attempts to bring them closer together. Looking at the evidence from behavioral science through our conceptual lens, we can see that spillovers are documented extensively across a variety of fields and domains: Fig. 2 summarizes the main types of promoting, permitting, and purging spillovers.

3. Promoting spillovers

The two archetypical promoting spillovers are the *cognitive dissonance* (Bem, 1972; Festinger, 1957; Festinger & Carlsmith, 1959) and the *foot-in-the-door* effects (Burger, 1999; Freedman & Fraser, 1966; Pliner, Hart, Kohl, & Saari, 1974). What they have in common is that both essentially posit a *preference for consistency* (Alberracin & Wyler, 2000; Cialdini, 1984; Cialdini et al., 1995): we tend to behave consistently with our prior actions and beliefs. So, for instance, if we have already agreed to a relatively costless request (e.g. signing a petition in favor of '*Keeping California Beautiful*'), we are more likely to agree to another more costly request (e.g. displaying a large signboard in the front lawn supporting safe driving) (Burger, 1999; Freedman & Fraser, 1966). In an all-negative analogy, if we have already rejected a highly demanding initial request, we are less willing to grant a smaller request later on (DeJong, 1979).

In some ways analogous to von Heisenberg's *uncertainty principle* in physics, the *intention-behavior effect* posits that the mere measurement of intention can have an influence on subsequent behavior (Morwitz & Fitzsimons, 2004; Morwitz, Johnson, & Schmittlein, 1993). Simply asking people whether they intended to vote increased their actual participation in the following day's elections, whereas merely measuring purchasing intention led to higher purchases of PCs or cars (Fitzsimons & Morwitz, 1996).

Similarly, in *question-behavior* and *survey effects*, the mere fact of answering hypothetical questions or being surveyed can remind subjects of a motive not previously attended to (Fitzsimons & Moore, 2008; Fitzsimons & Shiv, 2001; Fitzsimons & Williams, 2000; Levav & Fitzsimons, 2006; Moore, Neal, Fitzsimons, & Shiv, 2012). Households assigned to more frequent health surveys, one year later had higher levels of chlorine in their stored drinking water, or were more likely to take up health insurance (Zwane & et al., 2011). Consumers who, during a door-to-door survey, were asked to imagine themselves subscribing to cable TV, few months later were more likely to actually subscribe to it than neighbors who just received information about the service (Gregory, Cialdini, & Carpenter, 1982).

Rationality crossovers promote the use of economic rationality from a behavior occurring in market-like settings (e.g. a choice between two lotteries in presence of arbitrage), to a subsequent behavior taking place in the absence of financial incentives (e.g. non-market valuation of willingness to pay) (Cherry, Crocker, & Shogren, 2003; Cherry & Shogren, 2007). Similar forms of *extrapolation* have been documented by experimental economists looking at the links between the lab and the field (Harrison & List, 2004; Levitt & List, 2007a, 2007b; Levitt, List, & Reiley, 2010). Successful skills and heuristics evolved in some familiar situations carryover to other similar field or lab settings: for instance, experienced sports-cards dealers did not fall prey to the typical winner's curse in a lab auction (Harrison & List, 2008), whereas professional football players played more equilibrium strategies than students in laboratory coordination games (Palacios-Huerta & Volji, 2008). These

rationality crossovers are conceptually close to some of the *semantic* or *procedural priming* effects documented in the psychology literature (Forster, Liberman, & Friedman, 2007; Gollwitzer et al., 1990; Kruglanski et al., 2002; Neely, 1977).

Experiments in game theory have found that playing a sequence of two different strategic games is not the same of playing one of the games in isolation (Knez & Camerer, 2000). Two distinct *cross-games spillovers* can occur, both of which are essentially promoting spillovers (Bednar, Chen, Liu, & Page, 2012). First, players can learn about the structural properties of a game and transfer this knowledge to another game, e.g. whether the game is a coordination game (*structural learning*, *cross-games learning*: Cooper & Kagel, 2003; Huck, Jehiel, & Rutter, 2011; Mengel & Sciubba, 2010). Second, when playing a game, subjects can resort to cognitive or behavioral heuristics developed while playing *another* game (Bednar et al., 2012). If subjects had previously bid more aggressively in an auction, they next tended to contribute less in a subsequent public good game (Cason & Gangadharan, 2013; Cason, Savikhin, & Sheremeta, 2012; Savikhin & Sheremeta, 2013). Low donors to a charity cooperated less in a subsequent, unrelated, prisoners' dilemma game (Albert, Guth, Kirchler, & Maciejkovsy, 2007). Players managed to coordinate their moves more efficiently in a game if they had previously played another game in which they had experienced efficient coordination (*precedent*: Knez & Camerer, 2000) (Ahn, Ostrom, Schmidt, Shupp, & Walker, 2001; Devetag, 2005; Knez & Camerer, 2000). If subjects had played a structurally similar (different) game before, they were quicker (slower) to achieve equilibrium in another game (Grimm & Mengel, 2012).

Carryover effects of emotions and *self-herding* suggest that incidental emotions not only directly affect decisions at an unconscious level, but also indirectly spillover on other subsequent choices and actions taking place long after the initial emotional experience (Harlé & Sanfey, 2007; Lerner, Small, & Loewenstein, 2004). This is because, when we look back to our initial behavior, we tend to misattribute it to some of our deep preferences rather than to a fleeting emotion, and we choose our subsequent actions to follow suit the same inferred path (Andrade & Ariely, 2009). For instance, subjects who first watched a video that induced anger were not only more likely to reject unfair offers in a following, unrelated, ultimatum game than subjects who watched a happy video; but also made fairer offers to their partners in a subsequent dictator game, and even in a second ultimatum game where they acted as proposers (Andrade & Ariely, 2009). Conceptually similar is the already discussed *self-signaling* or *self-inference* tendency (Bénabou & Tirole, 2011; Gneezy, Gneezy et al., 2012). For instance, wearing counterfeit sunglasses can send a self-signal that we are cheaters, which can then lead us to actually cheat more when reporting our performance in a math puzzle task (Gino, Norton, & Ariely, 2010).

According to the *what-the-hell* effect, another all-negative promoting spillover, once individuals decide upon a course of behavior that is inconsistent with a motive (a diet), they are less likely to take the middle ground (low fat cookie) and more likely to exacerbate their failure to behave in line with the motive (eating the whole bag of cookies) (Herman & Mack, 1975; Herman & Polivy, 2010; Urbszat, Herman, & Polivy, 2002). Similar *abstinence violation* effects have been documented among alcoholics (Collins & Lapp, 1991), smokers (Shiffman et al., 1996), and drug users (Stephens & Curtin, 1994).

4. Permitting spillovers

Ego depletion is perhaps the 'classic' case of *permitting* spillovers: after having exerted high levels of self-control or effort in the first behavior, the same subject exerts lower levels of effort or self-control in the second behavior. Having resisted the temptation of indulging in sweets, or stifled emotions in emotion-arousing movies, subjects gave up earlier in impossible-to-solve puzzles (Baumeister, Bratslavsky, Muraven, & Tice, 1998). Having completed a difficult puzzle, subjects were more likely to cheat on their performance in an ostensibly unrelated task (Mead, Baumeister, Gino, Schweitzer, & Ariely, 2009). Ego depletion has physiological roots, in that to exert self-control we draw from a limited pool of mental energy: physical, but also mental activities consume energy that is converted from glucose into neurotransmitters (Baumeister & Vohs, 2007; Baumeister, Vohs, & Tice, 2007; Gailliot et al., 2007).

Moral licensing is a *permitting* spillover where, after having done 'well' in behavior 1, we act as if we have earned the moral entitlement to reward ourselves in behavior 2. Using the metaphor of a 'moral bank account', good deeds establish moral credits that can be withdrawn to purchase the right to undertake 'bad' actions. Subjects who, in a hypothetical choice to appoint a manifestly better candidate for a job, had the chance to establish they were not racist or sexist, were more likely to make prejudiced choices in a subsequent harder hiring decision (Monin & Miller, 2001). Subjects who said they were endorsing Obama in political elections, then allocated money to a charity fighting poverty in a white rather than in a black neighborhood (Effron, Cameron, & Monin, 2009). Advisors who disclosed their conflict of interest to advisees provided more biased advices (Cain, Loewenstein, & Moore, 2005). Subjects who first imagined teaching homeless children were less likely to donate to a local charity part of the experimental earnings, and made more frivolous purchases afterwards (Khan & Dhar, 2006; Strahilevitz & Myers, 1998).

Other related 'permitting' spillovers are the *resting on laurels effect*, by which seeing a progress as a sub-goal makes us spending less effort toward the final goal (Amir & Ariely, 2008); the *single-action bias*, by which an initial motive-directed action induces the impression that no further action is needed, even when is actually beneficial (Weber, 1997); the *reverse foot-in-the-door* effect, by which having said 'yes' to a request (e.g. signing a petition in favor of greater government aid for the homeless) leads to say 'no' to another request later on (e.g. volunteering to help at a canned food drive for the homeless) (Guadagno, Asher, Demaine, & Cialdini, 2001); and the already mentioned '*coasting*' tendency, by which after having exceeded our target rate of progress, we typically 'ease back' subsequent effort for the same motive (Carver, 2003).

5. Purging spillovers

Moral cleansing (or '*Lady Macbeth effect*') is the reverse of licensing: a *purging* spillover where, after having done 'badly', we act as if we need to restore our integrity. Subjects who hand-copied a story describing in the first person an unethical act, manifested higher desirability of cleansing products over neutral items, and, when offered the choice between an antiseptic wipe and a pencil, were more likely to take the antiseptic wipe (Zhong & Liljenquist, 2006). Participants who recalled a past unethical deed but also had cleansed their hands with an antiseptic wipe volunteered less to help out a colleague (Zhong & Liljenquist, 2006). Subjects who first hand-wrote a story using words for negative traits gave more to a local charity (Sachdeva, Iliev, & Medin, 2009), while participants who were induced to lie to a fictitious person on the phone, preferred mouthwash over soap, whereas the opposite held for subjects induced to lie in an email (Lee & Schwarz, 2010).

Similarly, the *conscience accounting* effect posits that people who have earned a given payoff by lying or stealing are more likely to donate to a charity than subjects who have earned the same amount without deceiving: anticipating this, subjects lied more when they knew that there would be an opportunity to donate immediately afterwards (Gneezy, Imas, & Madarasz, in press).

Other 'purging' spillovers related to moral cleansing are the *transgression-compliance* effect and the *negative state relief* by which, after that our personal values or moods (respectively) are affected by a negative state, we tend to act more altruistically in the attempt to restore them (Carlsmith & Gross, 1969; Manucia, Baumann, & Cialdini, 1984). Subjects led to believe that they had harmed someone else, were then more likely to comply with a request or to help a third person when given the opportunity (Manucia et al., 1984). Subjects with artificially 'lowered' mood but who also received an unexpected gratifying praise, however, no longer had to act altruistically to restore their mood (Manucia et al., 1984).

The *moral balancing* and *self-concept maintenance* effects share the same 'compensatory ethics' idea of both moral licensing and cleansing (Zhong, Ku, Lount, & Murnighan, 2010), and posit that people who think highly of themselves in terms of honesty behave dishonestly only to the extent to which they can retain their positive views of themselves (Mazar et al., 2008; Nisan & Horenczyk, 1990): when given the possibility to cheat on their payments with no consequences, subjects cheated only about 20 percent of the maximal possible amount they could get away with (Mazar et al., 2008).

6. Facilitating conditions for promoting, permitting, and purging spillovers

Spillovers from one behavior to the next could thus lead to either amplify or offset the initial intervention effect on the motive. From both the research and the policy perspective it seems imperative to explore under which conditions behavioral spillovers are more likely to manifest themselves as promoting, permitting, or purging: when is an initial nudge likely to feed into a further push to the motive, and when instead into a push-back?

There is, surprisingly, relatively little systematic research on this key point (Fishbach et al., in press; Susewind & Hoelzl, 2014). Mazar and Zhong (2010), for instance, explicitly compare *priming* and *licensing* effects. Subjects who previously were merely exposed to a store selling green items, then, in an ostensibly unrelated dictator game, shared more money than those who were exposed to a conventional store. This pattern, however, completely reversed when subjects selected products to purchase: participants who had purchased in the green store shared *less* money in the dictator game than those who had purchased in the conventional store.

Looking more broadly at the various literatures in the behavioral science, it is possible to identify at least five main streams of research that have looked at the boundary conditions that facilitate the occurrence of promoting, permitting, and purging spillovers. They focus, respectively, on: (i) the relative costs of behavior 1; (ii) the completeness of behavior 1 and its interaction with the focus of attention; (iii) the concreteness and the (temporal or spatial) proximity of behaviors 1 and 2; (iv) the trade-offs between different motives, or between a motive and a resource; and, finally, (v) the cognitive mindset during the two behaviors. In what follows we try to distill and summarize the state-of-the-art evidence from those streams of literature.

On (i), Gneezy, Imas et al. (2012) explicitly investigate the role of different costs of behavior 1 on the type of spillover. They find that subjects who donated part of their own earnings to a charity were less likely to deceive their counterpart in a subsequent sender–receiver game, while subjects who participated into a costless charitable donation were *more* likely to lie. This suggests that permitting spillovers are more likely over promoting when the costs of behavior 1 are low. High costs, in fact, self-signal the commitment toward the motive in question. Dolan and Galizzi (2014) link these findings to the distinct literature on financial incentives in health: they focus on whether incentives targeting one health behavior (physical exercise) spillover to another non-targeted health behavior (healthy eating), and find that spillovers are more likely to manifest themselves as permitting when the incentives associated to behavior 1 significantly outdo its costs. Relatedly, and in line with *counter-attitudinal advocacy*, promoting spillovers are less likely to occur when we can attribute our behavior 1 to an external cause, such as being paid or coerced to do something (Pittman, 1975; Zanna & Cooper, 1974). The different overall costs of behavior 1 can also explain why in some situations encountering and resisting a temptation can automatically activate the weight attached to a motive and thus lead to promoting spillovers, as postulated by *counteractive control theory* (Fishbach et al., 2003; Kroese, Evers, & De Ridder, 2009, 2011), while in other occasions it can trigger permitting spillovers through the activation of *justification* and *entitlement* feelings (De Witt Huberts et al., 2014; Hsee, 1995; Kivetz & Simonson, 2002; Kivetz & Zheng, 2006; Merritt et al., 2010; Mukhopadhyay & Johar, 2009). The literatures on justification

and entitlement, in fact, show that what matters for self-regulatory dynamics are *perceived* costs and efforts, rather than their actual levels (Clarkson, Hirt, Jia, & Alexander, 2010; De Witt Huberts, Evers, & De Ridder, 2012; Kivetz & Zheng, 2006; Werle, Wansink, & Payne, 2011).

On (ii), Fishbach et al. (in press) argue that permitting spillovers are more likely over promoting when, while pursuing a goal, individuals focus on completed, rather than missing, actions. This is because, generally, missing actions increase motivation by self-signaling a need for progress. This, however, depends on the underlying motive and focus of attention (Marsh, Hicks, & Bink, 1998). Similarly to what discussed above, Fishbach and Dhar (2005) argue that what really matters is the *perception* of progress rather than its objective level. Attention to completed actions, in fact, signals personal commitment and increases motivation when we are not yet committed to our goals, while attention to missing actions signals a need to progress and increases motivation when we are already committed.

Fishbach et al. (in press) observe that this combines with the so-called '*goal-gradient hypothesis*': regardless of the focus of attention, motivation increases with proximity to a goal's end state (Brown, 1948; Forster, Higgins, & Idson, 1998; Hull, 1932; Kivetz, Urminsky, & Zheng, 2006). For instance, consumers in a coffee-shop's '*buy 10, get 1 free*' program (a song-rating website) accelerate their purchases (site visits) as they get closer to the final reward (Kivetz et al., 2006). A simple psychophysical explanation of the *goal-gradient* effect is that '*the last action accomplishes 100% of the remaining progress, which is twice the impact of the second-to-last action*' (Fishbach et al., in press, p. 39). Using a similar psychophysical argument, Fishbach et al. (in press) observe that, when striving toward a goal, we are more motivated when we focus on whichever is smaller in size between the completed and the missing actions. According to this '*small-area hypothesis*', at the beginning of goal pursuit, when our commitment is typically low, the focus on completed actions increases motivation by signaling commitment, while later on, beyond the midpoint, the focus on remaining actions increases motivation by self-signaling need to progress (Fishbach et al., in press). This potential mechanism for promoting spillovers would also explain why motivation is typically lower in the middle of goal pursuit, a phenomenon known as '*stuck in the middle*' (Bonezzi, Brendl, & De Angelis, 2011).

On (iii), Conway and Peetz (2012) find that permitting spillovers are more likely over promoting when we visualize behavior 1 in a concrete and tangible fashion. This is because abstract construals tend to activate self-identity considerations, while concrete constructs may activate self-regulatory or compensatory mindsets (Trope & Liberman, 2003). For instance, subjects who were asked to describe how they would perform a '*fair, friendly, generous*' behavior donated less money to a charity than subjects who described how they would perform an '*unfair, unfriendly, greedy*' behavior, whereas no difference was found for subjects discussing what those traits would mean for their personality. Similarly, subjects who were asked to make concrete plans to exercise later that day, consumed more sweet snacks in a subsequent tasting test than control subjects who only wrote abstract statements (Kronick & Knauper, 2010). Coherently with the idea that distal events are perceived in a more abstract way, while temporally proximate events are perceived more concretely (Liberman, Sagristano, & Trope, 2002; Trope & Liberman, 2003), the same pattern emerged when concreteness was manipulated in terms of recalling deeds '*within the past week*' (concrete), as opposed to '*over one year ago*' (abstract). Similarly, Fishbach and Zhang (2005) find that permitting spillovers are more likely over promoting when in each behavior the two options (e.g. healthy and unhealthy food items) are physically presented together, and they seem to complement each other. Conversely, promoting spillovers are more likely to occur when the two options appear spatially apart, and seem to compete against each other.

On (iv), Dhar and Simonson (1999) propose that promoting spillovers are more likely in situations where each behavior involves a trade-off between a motive (e.g. pleasure) and a resource (e.g. money): for instance, after having chosen a tasty, expensive entrée over a less tasty, less expensive entrée, we are more likely to choose a tasty, expensive main course over a less tasty, less expensive one. Permitting spillovers, however, are more likely to occur in situations where each behavior involves a trade-off between two motives (e.g. pleasure and health): for instance, after having chosen a healthy entrée over a tasty one, we are more likely to prefer a tasty, over a healthy, main course.

On (v), Cornelissen, Bashshur, Rode, and Le Menestrel (2013) argue that permitting spillovers are more likely over promoting when we are in an outcome-based mindset rather than a rule-based mindset. The reason is that in an outcome-based (consequentialist) mindset we appraise the consequences of each behavioral alternative both for ourselves and for the others involved, allowing us to be relatively flexible when trading off different motives. Moral rules, at the contrary, do not naturally lend themselves to such trade-offs, because 'a rule is a rule'. They find that subjects who recalled a past episode that they thought was ethical '*because it benefitted other people*' (outcome-based mindset) cheated more in their payments than subjects who recalled a past episode that was unethical '*because it hurt other people*'. In contrast, subjects asked to recall a past episode that was ethical because they did their *'duty to follow an ethical norm or principle*' (rule-based mindset) cheated less in their payments than subjects who recalled a past episode that was unethical because they did not their duty.

More broadly, it should be noted that exploring under which conditions spillovers are most likely to be promoting, permitting, or purging, is a necessary but not a sufficient condition to be able to draw conclusions on the overall effect of a sequence of behaviors. Both researchers and policy-makers, in fact, would typically be interested also in quantifying the relative magnitude of behavioral spillovers. There is virtually no evidence at date, in the lab nor in the field, from systematically testing head-to-head two or more types of spillovers, with the objective of measuring their relative strength, magnitude, and persistence over time. Quantifying the magnitude of permitting and purging spillovers, in particular, is imperative in order to disentangle 'rebound' from 'backfire' (or 'boomerang') effects (Gillingham et al., 2013; Goeschl & Perino, 2009; Jacobsen et al., 2012; Jenkins, Nordhaus, & Shellenberger, 2011): although the two terms are often used interchangeably, from a policy

perspective it is crucial to conceptually distinguish when the net effect of the two behaviors results in an overall increase or decrease in the behavioral outcome (Tiefenbeck et al., 2013).

7. Future directions and challenges

Lab and field experiments across all the behavioral sciences thus show that behaviors are history-dependent and that spillovers are pervasive. From the methodological perspective, this reinstates the importance of the current best practices by lab researchers of counter-balancing sequences of tasks and explicitly controlling for order effects. It is encouraging to see that field and online experiments increasingly adhere to such practices even in settings which are naturally less controllable than the lab.

Evidence shows that spillovers occur through deliberation and also unconsciously. This confirms the importance of considering a broad operational definition of behaviors and motives, consistent with the recognition of the major role of automatic, involuntary, and unconscious processes in human decisions and behavior (Aarts & Dijksterhuis, 2000; Bargh & Chartrand, 1999; Chaiken & Trope, 1999; Chartrand & Bargh, 2002; Chartrand, Huber, Shiv, & Tanner, 2008; Dijksterhuis & Nordgren, 2006; Fitzsimons et al., 2002; Kahneman, 2003, 2011; Wilson & Schooler, 1991). Our framework can be used to consider the ripple effects of sequences of behavior and not just the initial splash from the first behavioral response. As such, it provides the glue that can help to hold together our understanding of the conscious and unconscious spillovers from one behavior to the next. It also provides a useful lexicon for researchers and policy decision-makers from different fields and perspectives.

From a research and policy perspective, we should abandon 'behavioral silos' and 'sector-thinking' (Thøgersen, 1999a). The impact of a policy intervention can be greatly enhanced in presence of promoting spillovers, but it can also be severely hindered, or completely jeopardized, by the occurrence of permitting effects. And this is to further disregard the possible role of purging spillovers as potential levers to trigger envisaged changes in behavior.

There are a number of outstanding issues. Most of the evidence to date documents the occurrence of spillovers within short temporal horizons. We know very little about the longevity of spillovers beyond the time frame typically considered in lab experiments (Fitzsimons & Morwitz, 1996; Gregory et al., 1982; Tiefenbeck et al., 2013; Zwane et al., 2011). The design of field experiments in naturalistic settings is practically challenging if one really wants to map all possible ramifications of a behavior. This gap in the evidence calls for a further integration of longitudinal surveys and experimental methods in behavioral science, and for higher efforts to link experiments, administrative records, and 'big data' that are already available (Dolan & Galizzi, in press).

Future efforts should also be directed toward understanding the contexts and domains under which spillovers are most likely to take place. Most of the evidence at date, in fact, considers spillovers occurring within the same domain, such as environmental behavior (Evans et al., 2013; Jacobsen et al., 2012; Lanzini & Thøgersen, 2014; Poortinga, Whitmarsh, & Suffolk, 2013; Thøgersen, 1999a, 1999b; Thøgersen & Crompton, 2009; Thøgersen & Olander, 2003; Tiefenbeck et al., 2013); prosocial behavior (Brañas-Garza, Bucheli, Espinosa, & Garcia-Muñoz, 2013; Cornelissen et al., 2013; Effron, Miller, & Monin, 2012; Gneezy, Imas et al., 2012; Gneezy et al., in press; Jordan, Mullen, & Murnighan, 2011; Merritt et al., 2010, 2012; Norton, 2012; Ploner & Regner, 2013; Zhong & Liljenquist, 2006); or health behavior (Chiou, Wan, Wu, & Lee, 2011; Chiou, Yang, & Wan, 2011; De Witt Huberts et al., 2012; Dolan & Galizzi, in press; Effron, Monin, & Miller, 2013; Epstein, Dearing, Roba, & Finkelstein, 2010; Kroese et al., 2009, 2011; Van Kleef, Shimizu, & Wansink, 2011; Werle, Wansink, & Payne, 2010; Wilcox, Vallen, Block, & Fitzsimons, 2009; Wisdom, Downs, & Loewenstein, 2010).

There is little evidence on whether spillovers can occur across different domains, and whether such cross-domains spillovers are most likely to be promoting, permitting, or purging (Baird, Garfein, McIntosh, & Özler, 2012; Khan & Dhar, 2006; Mazar & Zhong, 2010; Sachdeva et al., 2009). Conceptually, such spillovers can be visualized as cross-motives links between self-images ('*I am healthy and environment-friendly*'), accounts weights ('*what makes me happy is working hard and being a good father*') or both. From the policy perspective, a comprehensive mapping of the links between behaviors, contexts, and domains will illuminate not only *which* areas to target to induce behavior change, but also *where* to start from (Thøgersen, 1999a). For example, does more responsible behavior at school feed into healthier choices, or what happens if we start by 'nudging' healthy behavior instead?

Evidence is also missing on whether behavioral spillovers are only related to specific contexts, domains, and situations, or whether they are also explained by differences across people, such as personality, cognitive skills, and socio-economic conditions (Borghans, Duckworth, Heckman, & ter Weel, 2008; Heckman, 2007a, 2007b; Heckman & Rubistein, 2001).

We should finally seek to better understand the neuro-physiological roots of behavioral spillovers. Research in neuroscience has substantially advanced our current understanding of the neural correlates of human decision-making and behavior (Camerer, Loewenstein, & Prelec, 2005; Glimcher, Fehr, Camerer, & Poldrack, 2008). The forthcoming efforts to thoroughly map the human brain will provide precious insights on how the numerous ripples documented here might spread through the complex network of our mind.

Notwithstanding these open questions, the time seems ripe to explicitly account for the pervasive impact of behavioral spillovers. Behavioral scientists, especially those seeking to inform policy, should try to capture all the ripples when a pebble of intervention is thrown in the pond, and not just the immediate splash it makes.

Acknowledgments

The project was funded by the Centre for the Study of Incentives in Health (CSIH), from a strategic award from the Wellcome Trust Biomedical Ethics Programme (PI Marteau: 086031/Z/08/Z). We gratefully acknowledge this funding. We thank the Editor and two anonymous referees for excellent comments and suggestions that have substantially improved the article. We also thank our colleagues at CSIH, Alex Imas, Heather Kappes, Natasha Perkins, and the participants to seminars at Aberdeen, Cologne, and LSE for helpful comments and suggestions.

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Exhibit P

Methodology

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Journal of Comparative Effectiveness Research

Analyzing the concept of spillover effects for expanded inclusion in health economics research

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Background: The incorporation of spillover effects in health economic research is recognized by regulatory agencies as useful for valuing health interventions and technologies. To date, spillover effects are not universally used within economic evaluations and conceptual definitions of spillover effects are vague within the context of health economics research. **Materials & methods:** In an effort to enhance awareness of spillover effects for health economic evaluations, a concept analysis using Walker and Avant's approach was performed to elucidate the key attributes, definitions, antecedents and consequences of spillover effects across a range of disciplines. **Results:** Key attributes included lack of intention, positive and negative impacts, and two entity/domain involvement. Antecedents included an initial action and desired outcome. Consequences involved spillovers across industries, work life to personal life domains, patient to family member domains and across healthcare markets. **Conclusion:** The analysis provides greater clarification around the dimensions of spillover effects and reveals opportunities to enhance methodological approaches to assessing spillovers.

First draft submitted: 1 April 2020; Accepted for publication: 1 June 2020; Published online: 17 June 2020

Keywords: concept analysis • economic evaluations • health economics • spillover effects

Health economic evaluations have been indicated to facilitate decision-making around medical interventions, technological advancement, pharmaceutical innovation, healthcare professional workforce projections and other healthcare-related topics [1–3]. Given rising US healthcare spending, information gleaned from economic evaluations can lead to the appropriate allocation of resources needed to improve patient outcomes, healthcare systems, health policy and other healthcare-related decisions [3].

Economic evaluations are commonly classified as cost–effectiveness analyses, cost–utility analyses and cost–benefit analyses [4]. The various economic evaluation techniques similarly compare costs in the form of monetary units and differ with regards to measuring consequences [4,5]. For example, cost–effectiveness analyses, as described by Drummond and colleagues [4], measure a single consequence in the form of a natural unit, such as blood sugar reduction, life years gained or averted missed work days. Cost–utility analyses can measure outcomes of interventions based on preferences or utility weights. Cost–utility analyses are considered a broader type of cost–effectiveness analysis. A common cost–utility measurement is the quality-adjusted life year [4]. Cost–benefit analyses focus on a single cost and benefit measurement in the form of a monetary unit alone [4,5]. The availability of multiple economic evaluation techniques is beneficial for evaluating health programs and interventions, as well as resource allocation decision making where value judgments may vary by research question or approach [4,5].

An important concept discussed in the health economics literature is spillover effects, known as the health impacts and costs that extend beyond a health intervention or program's targeted recipient (the patient) to unintentionally impact other recipients either in a positive or negative way [6,7]. Health economic studies have predominantly assessed spillover effects within the family unit, where a patient's health status spills over to impact the quality of life of a family member [6]. Despite acknowledgement by the Second US Panel on Cost–Effectiveness in Health and Medicine that spillover effects are needed to enhance cost and benefit estimates of health interventions, a gap exists

Future Medicine

Table 1. Spillover effect concept characteristics.

Attributes	Antecedents	Consequences
• Unintentional • Positive or negative impacts • Two entity/domain involvement	• Initial action • Desired outcome	• Unintentional impact from one entity to a second entity • Cross-industry, interpersonal, professional life to personal life domain

in health economics research regarding universal inclusion of such effects [8]. A potential cause of such spillover effect exclusion could be uncertainty around the concept of spillover effects, given the existing focus in health economics on the family caregiver spillover domain [9,10].

The purpose of this analysis was to examine the concept of spillover effects in order to identify defining attributes, antecedents and consequences across a variety of academic disciplines. An expanded analysis of the concept across multiple disciplines can inform increased integration of spillovers within health economic evaluations. Additionally, an analysis of the concept may expand the types of spillovers evaluated in health economic studies. The concept analysis consists of an eight-step process outlined in subsequent paragraphs, followed by implications for health economics research.

Concept analysis of spillover effects

In analyzing the concept of 'spillover effects', a systematic eight-step procedure was conducted using Walker and Avant's concept analysis process [9]. The Walker and Avant [9] concept analysis process consists of: selecting a concept, determining the purpose(s) of the analysis, identifying uses of the concept, defining attributes, identifying a model case, identifying contrary cases, identifying antecedents and consequences and defining empirical referents. The first two steps of Walker and Avant's approach (concept selection and purpose development) are addressed in the introduction; the remaining steps are discussed in the following sections [9].

Materials & methods

The concept of interest for the analysis was spillover effects, which is identified in a variety of terms in the literature as 'spillovers', 'spillover effects' and 'externalities' among a wide range of academic disciplines. These terms were all considered related to the identified concept of spillover effects. For the analysis, the literature search was restricted to health economics, psychology, sociology and business. A comprehensive search of the literature was conducted using PubMed, Google Scholar and Ovid Medline to understand the range of definitions and uses of spillovers. The primary search terms and Medical Subject Headings terms used either in combination or alone were 'spillover', 'spillover effects', 'externalities', 'economic', 'economic evaluation', 'economic modeling', 'Markov', 'cost–effectiveness', 'health', 'nurse', 'nursing', 'physician', 'caregiver', 'psychology', 'sociology' and 'business'. The search was filtered such that keywords were identified in the title and abstract of the articles. The article inclusion criteria included: articles or white papers that included the words 'spillovers' or 'externalities' written in English language within the past 15 years. Papers published in non-peer-reviewed journals, as well as gray literature and editorials were included.

A total of 50 articles that met the inclusion criteria were initially reviewed. A total of 34 articles were selected [10–41,44,45]. A total of 21 articles were from the health economics discipline, six from psychology, four from sociology and three from business. The majority of excluded articles discussed mathematical modeling of spillover effects, which was not relevant to the current research topic. The identified literature was reviewed and analyzed to identify attributes, antecedents and consequences of spillover effects (Table 1).

Identifying uses of the concept

The initial step of the analysis involved examining the definition of 'spillovers' in the dictionary and uses in the relevant published literature. According to Merriam-Webster [42], 'spillover' refers to 'an extension of something, especially when an excess exists'. Use of the term 'spillover effects' are discussed in the following sections within the domains of health economics, psychology, sociology and business. A total of 23 of the articles explicitly described a definition of spillover effects, while the remaining articles described examples without clear definitions.

Uses in health economics

Spillover effects were examined within the academic discipline of health economics and were discussed as either 'spillovers', 'spillover effects' or 'externalities'. Within the health economics field, spillovers were most commonly discussed in relation to a health intervention, scientific advancement or technological development. Gold [7], discusses spillovers, synonymous with externalities, as a positive or negative market exchange impacting individuals or groups who are not direct participants in such exchanges (p. 66). In a case study discussion on measuring spillover effects of patients with meningitis, Bhaduri and colleagues [22], refer to spillovers as 'wider health benefits' impacting patients in addition to individuals who are close to the patient (p. 1). Lakdawalla and colleagues [26], defined spillovers within the concept of scientific spillovers as the benefit of a scientific advancement imparted upon future knowledge development. Scientific spillovers occur when one advancement is made and other scientists, researchers or innovators expand on the given idea or advancement over time.

Much of the health economics literature studied spillovers in the context of the family caregiver or informal carer. Caregiver spillover effects, first introduced by Basu and Meltzer [6], refer to the various conditions, treatments and contacts that impact the welfare of family members. Spillovers manifest as the caregiver health effects and/or informal care time costs resulting from the health status/condition of a family member or close individual [13]. Spillovers have also been explored in terms of their impact on healthcare markets and provider practice patterns. A study by Johnson and colleagues [27], posited that decreases in fee-for-service traditional Medicare spending resulted from the spillover effect of increased Medicare Advantage penetration within states. Baicker and Robbins [16], found that a 10% increase in Medicare Advantage state penetration was associated with an approximate US$250 reduction in fee-for-service traditional Medicare resource use per patient. Cost-controlling measures within Medicare Advantage, such as the presence of health maintenance organizations, resulted in decreased costly inpatient hospitalizations and more cost-reducing outpatient service use. Overall, the health economics literature considered spillovers the impacts that extend beyond a patient and impact individuals or groups within a social network of a patient.

Uses in psychology

Within the psychology discipline, spillovers were discussed as an attitudinal or behavioral transfer from one life to domain to another [30,32]. In studying shift work among nurses with families, Kunst and colleagues referred to spillovers as "*. . . transfers of mood, energy and skills from one sphere to another*" [30]. Spillovers were described in psychology as bidirectional in movement, occurring between work and family life domains [30]. Behavioral spillovers were a particular domain of spillovers in the psychology literature defined as a secondary process that can lead to larger-scale societal and scientific consequences [33]. Nash and colleagues described behavioral spillover theory as, "*a way to catalyze broad lifestyle change from one behavior to another in ways that generate greater impacts than piecemeal interventions*" [34]. Behavioral spillovers have been contextualized within environmental impacts within countries, where the concept of a conscious spillover can be cultivated in countries that value pro-environmental behavior [34]. Additional behavioral spillovers have evaluated exercise and healthy eating practices [34]. Overall, spillovers in psychology emphasized behaviors and the transfer of emotional or behavioral influences from one life or societal domain to another.

Uses in sociology

Uses of spillover effects in the sociology literature shed light on intersections between individual disparities, institutions and social outcomes. Timmermans and colleagues situated their qualitative study on lack of health insurance spillovers based on neoclassical economic underpinnings [37]. Within this study, spillovers were discussed as 'collateral effects' and 'externalities' that are costs or benefits resulting from activities impacting "*an otherwise uninvolved party who did not choose to incur that cost or benefit*" [37]. Spillovers were further described as a tool to examine the effects of activities between entities that are unrelated but seemingly impacted by one another [37]. In studying the spillover effects of deterrence strategies to reduce crime, Braga and colleagues did not explicitly define spillover effects, but reference them as synonymous with indirect effects [38]. Hagan and Foster [36], assessed spillovers in the context of incarcerated mothers and the associated 'social costs' incarceration can have on children's education. Thus, the identified sociology literature referred to spillovers as the unintentional impacts of a policy, process, or phenomenon on societal institutions and outcomes.

Uses in business

In the business literature, spillovers were discussed in the context of innovation and idea expansion between groups. Frischmann and Lemley [39], define spillovers as the, "*uncompensated benefits that one person's activity provides to another*". Grillitsch and Nillson [41], examined knowledge spillovers in Swedish firms that are located within industrial 'clusters' or regions of high local knowledge density versus firms that are located within a knowledge 'periphery'. The study found that innovative firms in the knowledge periphery collaborate with external firms to compensate for the lack of knowledge spillovers that are gained by firms located within the knowledge/industrial cluster [41].

In a business advertising context, Sahni analyzed the impact of online advertisements on advertiser competition [40]. The findings from the randomized field experiments from a restaurant-search website suggested that spillovers were significant when advertising efforts were of the lowest frequency, while minimal spillovers occurred with high-intensity advertising techniques. Thus, the stronger intensity advertising techniques saturated consumer interest in the main advertiser, which offset spillovers toward other competitors [40]. Business spillover effects in the identified literature referenced spillovers in the context of innovation, marketing influences and consumer activities.

Defining attributes

The determination of defining attributes is central to identify and define characteristics central to the concept under study. Based on the relevant review of the literature, three common attributes of spillover effects were noted: lack of intention, positive or negative impacts and two entity/domain involvement.

Lack of intention (unintentional)

The majority of the literature examined described spillovers as unintentional in nature. Frischmann and colleagues [38], described spillovers as never planned nor calculated from the outset of an activity, process, intervention, or phenomenon. Thus, the receiving individual or third party is not privy to a transaction or compensations [19,22,39]. Sahni discusses the unintentional nature of advertisement techniques that invoke consumer memory recall of associated brands or products [40]. The literature described advertising techniques as having an unintentional consequence of priming a consumer to recall a non-advertised option in addition to the primary product/service advertised [40]. Health economics spillover effects around health interventions were described as an unintended effect on informal caregivers, family members, or other individuals within the social network of a patient. The majority of the identified spillover literature in the psychology and sociology disciplines discussed spillovers within the frame of being unintentional. One domain of psychology with a greater level of intentionality described was within behavioral spillovers specifically within environmental research. For example, Nash and colleagues [34] described behavioral spillovers as strongly influenced by "*behavioral interventions, changes in awareness, availability of infrastructure and resources and technological advances and policy change.*" Across the identified literature, spillovers were not intentionality imparted upon the indirect recipient.

Positive or negative impacts

Each of the disciplines characterized spillovers as capable of causing positive or negative effects. Within the realm of business and innovation, spillovers were cited as a social benefit that expands the influence of ideas to wider groups [39,40]. The social benefit of such a spillover is viewed as the advancement of an idea or innovation for the benefit of an industry. Furthermore, ideas cultivated in one industrial field were considered to commonly spill over into other fields – considered an interindustry spillover – in which case the benefit of these spillovers are accrued by both fields [39]. Frischmann and Lemley [39] attributed, in part, the 1980s computer boom to positive spillovers effects due to knowledge spillovers moving freely within Silicon Valley. Similarly, Grillitsch and Nillson's examination of knowledge spillovers between firms further supports the notion of positive innovation spillovers within regional clusters [41]. The study demonstrated that innovative spillovers between firms is positive, valuable and firms will strive to obtain these spillovers either through geographical means (internal access) or through collaborations externally [41]. Sahni discussed spillovers within advertising as positive or negative, based on the advertising effort companies implement [40]. Lower frequency advertising strategies resulted in positive spillovers for the advertising company's competitors, while higher frequency techniques resulted in positive spillovers for the advertising company.

In the discipline of psychology, spillovers have been described as both positive and negative within the work–family life spheres. Amstad and Semmer [32] describe work as a positive spillover where workers can develop

beneficial time management and efficiency habits that benefit productivity and communication within the family unit. Conversely, work is described as a negative spillover when stress transfers from the work domain to the home life domain [32]. Negative spillovers manifest as the undue stress imparted to family members by an employee ruminating at work within the family setting [31].

Much of the literature on spillover effects within health economics described the negative spillovers from a patient illness to a family member or individual close to the patient. Caregiver spillover effects, first introduced by Basu and Meltzer [6], refer to the various conditions, treatments and contacts that impact the welfare of family members. Such spillovers manifest as caregiver health effects and/or informal care time costs resulting from the health status/condition of a family member or close individual [13]. Al-Janabi and colleagues [22], describe family caregiver spillovers as the psychological, physical, financial and emotional burden that family caregivers experience while caring for a sick family member. Family caregiver spillovers have been studied among parents of children with medical complexity and autism, as well as spouses of adult patients; such effects include increased parent absenteeism, physical injury, depression and anxiety [10,12]. Bhadhuri and colleagues assessed meningitis family spillovers and found that long-term morbidity for meningitis survivors caused negative spillovers in the form of family member health losses [23]. Thus, negative spillover health impacts toward family members/caregivers predominated the health economics literature.

Two entity/domain involvement

A unifying theme across the spillover effect literature was the involvement of two entities or domains impacted by an action or process. Specifically, spillovers were described to have a direct impact on a targeted entity (or domain), as well as a second entity unintentionally. This common characteristic manifested within the business literature as innovation spillovers from one entity, or industry, to another. Within one sociology study, one family entity, an incarcerated mother, had an unintentional impact on her child's performance in the school domain [36]. An additional sociology perspective assessed the impact of a health insurance domain on societal institutions (schools and churches) [37]. Among the identified literature, there were noted similarities between psychology and health economics in that family members were the two entities frequently impacted by spillovers [10–13,30–32]. As mentioned previously, spillover effects studied within the psychology discipline assessed professional life spillovers to the home and family setting [30,32]. Within the health economics literature, spillover effects were most commonly referenced as well-being impacts on family members of patients. Further health economic studies referenced changes in innovation from a present scientific to future scientific domain [26].

Identifying a model case & contrary case

Model case

Model case construction is the fifth step of Walker and Avant's [9] concept analysis and consists of including the identified attributes in a model case based on literature or invention by the author. The following case was created by the author and discusses the spillover impacts of a healthcare unit systems-level intervention on patient outcomes.

Elkwood Hospital Emergency Department (ED) provides adult, pediatric and women's health services. It has a triage section, a main ED treatment area and a pediatric treatment area. Recently, the ED has experienced a surge in patient volumes due to local population growth. The department decides to implement a new triage workflow configuration for patients after identifying that 70% of all presenting ED patients are low acuity and do not need to be seen in the main ED treatment area. Thus, the department initiates a 'triage quick assessment' process facilitating quick assessment and treatment of low-acuity patients in order to free up bed and clinician resources for high-acuity patients and to reduce patient wait times.

In order to increase efficiency in the new triage center, patients are initially brought into a triage room after patient registration where vital signs, initial assessments and labs are taken by a nurse. After this process, the patient is returned to the waiting room where they wait to be called back into the triage room for a physician assessment. As the first patient waits in the waiting room, new low-acuity patients are brought into the triage room to go through the same process by the nurse.

The new triage configuration is efficient in that it facilitates a quick assessment of every patient, where a nurse can identify if a patient is truly stable (or not) and return patients to the waiting room until their physician assessment. The additional benefit of the quick assessment process is that it allows for continuous bed availability should a high-acuity patient present in need of immediate stability and subsequent transfer to a permanent room.

Over time, the ED observes significant drops in patient wait times due to this new configuration. However, although the process has benefited overall patient time metrics in the ED, the process has been detrimental to patient satisfaction ratings. Patients have reported negative feedback regarding the constant transport between the triage room and the waiting room and report perceived fragmented care imparted by the staff. Additionally, the department has observed a 10% increase in clinician turnover since implementation of the new triage configuration. Nurses on the unit cite increased moral distress due to the rising time pressures and increased time constraints related to quickly completing patient registration, assessments and labs. The physicians have reported missed nursing care on common tasks, such as incomplete vital signs and delayed medication administration. Upon closer evaluation, the director of the ED has noted rising patient re-admissions to the ED. Despite quick evaluations among these low-acuity patients, approximately 30% are returning within one week to the ED again.

This case addresses the defining attributes of spillover effects wherein the intervention resulted in unintentional impacts such as decreased patient satisfaction, clinician turnover, nurse moral distress, patient adverse events and increased patient re-admissions. The department did not intend from the outset for a systemic intervention to cause clinician moral distress impacting clinician performance and patient outcomes. The resulting spillovers of increased efficiency in one arena (reducing wait times) included increased clinician error detrimentally impacted patient outcomes and/or reduced patient satisfaction impacting patient utilization.

The case results in negative spillovers, evidenced by increased patient utilization, clinician error, moral distress and patient dissatisfaction. Though the same entities are involved (patients, clinicians and the emergency department), different domains, or 'arenas' as mentioned in the psychology literature base, are impacted. Overall, the primary intention of the intervention was to increase patient efficiency (domain 1), while a variety of secondary domains were unintentionally impacted through spillovers (patient satisfaction, quality of care delivery, clinician turnover, patient health status, patient utilization).

Model case: methods expansion

This case additionally highlights the need for close examination of the methods used to measure the identified spillovers. A mixed-methods approach could be used to elucidate such effects mentioned within the case, particularly within an economic evaluation [43,44]. For example, a cost–benefit analysis could be conducted to quantify the impact of the new triage intervention, with spillover effects evaluated through increased patient re-admission costs and clinician turnover-rate costs. Furthermore, qualitative methodologies could be used to elucidate the systemic impacts on clinician challenges linked to fulfilling the identified workflow. Mixed-methods approaches could be employed to assess the quantifiable aspects of these spillovers, with qualitative methods informing the moral distress, intention to leave the workplace and patient dissatisfaction [43,44]. Thus, a variety of measurement strategies could be employed to best understand spillovers in the context of a health system intervention.

Contrary case

An ED creates a triage configuration to rapidly assess patients. Upon evaluating performance metrics, ED identifies that on a daily basis, 70% of the total patients seen in the ED who are low-acuity patients are successfully being treated and discharged from this new triage configuration. The physicians and nurses who work in the main section of the ED have noticed that the time to treat patients who are high acuity has decreased, meaning clinicians are seeing the sickest patients faster than before the intervention. This is a contrary case to a spillover because the implementation of the new triage configuration is intended to increase efficiency for low- and high-acuity patients. The ED aimed to treat 70% of the patients through a rapid assessment configuration in order to increase time to treat efficiency for high-acuity patients. Only one domain is impacted in this case – patient efficiency – given that it is the ED's intent to reduce wait times for all patients due to a workflow change. Thus, this case lacks the attributes of two entities and being unintentional in nature.

Identifying antecedents

Antecedent identification helps to understand the characteristics of attributes of spillover effects that exist prior to fulfillment of the concept [9]. There are two antecedents of spillovers: an intentional first action and a desired outcome. The intentional first action is the act of delivering or implementing a primary process. The desired outcome is inherently linked to the first action. A first action would be considered, for example, the development of a new healthcare technology to help patients with chronic pain. The desired outcome of technological advancement would be to reduce a patient's perceived or pathophysiologic suffering from pain. An initial action and desired

outcome are an antecedent because it determines the first entity or domain impacted in the spillover effect cascade. The secondary aspect, or consequences of the spillover effect involves impacts to secondary entities. Consequences are discussed in subsequent paragraphs.

Identifying consequences

Consequences are resulting events or phenomena that emerge from the identified concept [9]. As previously described, consequences of spillovers are considered the unintentional impacts resulting from an intentional first action and can have positive or negative impacts. The magnitude of the spillover effect consequences varied among the disciplines reviewed and provided rich perspectives on micro- and macro-level impacts among various entities under study. For example, the business literature predominantly described spillover effects as having a large-scale impact as various industries were involved [39–41]. Geographic context strongly influenced the transference of knowledge and innovation spillovers [39,41].

Similarly, health economic spillovers were discussed in the context of scientific innovation, however the majority of studies discussed spillover impacts between individuals [26]. Specifically, individuals with illnesses and their social networks were the focus of health economic spillover effect research [19,20]. Health economic studies, therefore focused mostly on individual versus industry spillovers. A noted methodological consequence of measuring spillovers relates to the issue of double-counting [25]. An example is in the case of a patient experiencing depression or anxiety related to watching a family or clinician caregiver provide challenging care. This situation poses a methodological risk of double counting, in which the quality of life decrement is 'counted' as a utility for the patient when it could already be 'counted' in the utility of the caregivers [25].

The discipline of psychology also discussed smaller magnitude spillovers within the family unit, however behavioral spillover literature addressed environmental spillovers on a national level of larger magnitude [32,33]. Finally, spillovers within the sociology context assessed broader societal impacts of policies, processes, or access challenges [35–37]. Though individual family unit spillovers were assessed, a broader spillover focus was on societal impacts. The analyzed literature expressed a variety of spillover effect impacts that are important to consider in developing research around spillovers.

Identifying empirical referents

The final stage of Walker and Avant's approach [9] is identifying empirical referents, specifically how the concept is measured. The measurement of spillover effects was identified as highly variable across the various disciplines. Although definitions of spillovers across the disciplines overlap, there existed noted differences in the measurement of spillovers among the examined literature.

Spillovers evaluated within the fields of psychology, sociology and business have used both qualitative, quantitative and mixed-methods approaches to assess spillover effects. In the sociology context, Timmermans and colleagues [37] evaluated how lack of health insurance affects religious institutions and school (kindergarten–12th grade) functioning. Using in-depth, qualitative interviewing methods, the authors found negative education spillovers relevant to increased student absenteeism, as well as increased ED utilization rates and 'waiting illnesses out' (p. 367) [37]. In examining spillover crime impacts, Braga and colleagues [38] used a quasi-experimental design and regression analysis to examine gang shooting trends. During data collection for the study, the team employed qualitative interviewing to gain insight into shooting events, relationships between gang victims and other contextual information relevant to gun-related gang activity [38]. Spillover inclusion in the examined business literature has predominantly included quantitative regression analyses of market impacts or consumer behaviors [39,40].

Within the health economic literature, quantitative approaches to assess spillovers have dominated over qualitative approaches. Health economic studies have assessed spillovers using state-preference valuation techniques, such as surveys like the EuroQoL-5 Dimension (EQ-5D-3L) and the Short Form-6 Dimension (SF-6D) to assess individuals' health status [45,46]. Such surveys ask participants to rate their health within a wide range of dimensions such as sleep quality, anxiety/depression, pain/discomfort and more. Data from these surveys are then quantitatively evaluated using regression-based or correlational analyses to understand associations between patient health quality and caregiver quality to determine potential spillovers [23].

Additional spillover assessments in economic evaluations include discrete choice experiments, where caregivers are given a set of scenarios and are asked to select their preferences of variables/choices within specific scenarios [15]. Such assessments are useful in determining willingness-to-accept values regarding caregiver informal care payment [20,28].

Other spillover assessments include accounting for displaced time due to caregiving through opportunity costs in economic models and recording caregiver tasks in diary logs [13].

Qualitative approaches have been used sparsely in health economic studies [47]. One identified study by Canaway and colleagues [19] used in-depth interviewing and hierarchical mapping to identify the social networks of end-of-life (EOL) patients [19]. The authors found that EOL patient caregiving network size was dependent on disease trajectory; EOL patients had an average of eight close family members/and or caregivers. Information gleaned from the interviews can be used by economists to assess the emotional and personal connectedness spillover effects of EOL caregiving within a network [19].

Despite the use of mixed-methods and qualitative approaches in the fields of psychology and sociology, qualitative methodologies are less prominent in health economics literature. No general consensus existed among the selected literature on how to universally assess spillovers. The implications of the identified diverse approaches to assessing spillover effects is discussed in subsequent paragraphs.

Implications for health economics & comparative effectiveness research

Implications from this concept analysis include expanding the types of spillover effects assessed in economic evaluations, as well as the methods used to assess spillovers. First, this concept analysis demonstrates an opportunity to expand spillover effect analyses to include entities beyond family caregivers or scientific innovation advancement in the future. Health economic studies have evaluated spillovers between healthcare markets in a similar manner to inter-industry spillovers in the business literature. However, increased opportunity exists in quantifying spillovers beyond the patient social network to include frontline caregivers, systems-level spillovers of health interventions (i.e., increased outpatient clinic visits, ED re-admissions) and health intervention spillovers to manufacturing industries [19]. Additionally, there is a gap in understanding the existence of and potential impact of multiple spillovers occurring at the same time. Future research is needed to understand multidimensional spillovers, where, for example, an entity experiences multiple spillover effects at once. Family caregivers, for example, may experience health spillovers while informally caring for a sick loved one while simultaneously experiencing financial spillovers from a new medication for the patient's symptom relief.

Second, the examined methods used to assess spillover effects (empirical referents) from the examined literature can be applied to health economic studies to further elaborate on spillover effects comprehensively. Qualitative methodologies, for example, can be used to best elaborate on spillover effects that may be challenging to quantify in traditional spillover effect measures such as regression analyses, choice experiments or surveys. Dopp and colleagues [44] suggest that qualitative perspectives can facilitate mixed-method approaches in economic evaluations to fill a 'qualitative residual' where stakeholder and contextual information is traditionally absent (p. 2). The mixed approaches to assessing spillovers, for example in the sociology literature, where qualitative methods were used, suggests that spillovers may employ rich, descriptive contextual perspectives that are well-suited to compare health interventions [18,37]. Qualitative methodologies are well suited to assess spillovers due to inherent epistemological underpinnings in thick, contextual descriptions, emic–etic (insider, outsider) perspectives and observational data on drivers and mechanisms of topics under study [48–50,53]. Inclusion of qualitative methods to assess spillovers in economic studies may result in the investment of healthcare resources that are appropriately allocated to targeted populations. The subsequent section addresses factors to consider when integrating spillover effect assessments into health economic research.

Expanding spillover effect inclusion in health economic studies

Figure 1 can be used as a framework to guide spillover effect inclusion in health economic evaluations. Adapted from Galizzi and Whitmarsh's [29], methodological recommendations for behavioral spillovers, relevant questions to consider about spillover effect inclusion based on Figure 1 factors are listed below.

Context: What is the setting where the spillover effect(s) takes place?

Entities: What are the entities, domains and/or populations involved? What is the intended (directed) and unintended impact? What are any targeted interventions targeting directed outcomes?

Magnitude: What are the potential outcomes from the intended outcome? What is the breadth and depth of the impacts?

Methods: Can these spillovers best be elucidated through experimental or non-experimental approaches? Are there opportunities for qualitative or mixed-method approaches?

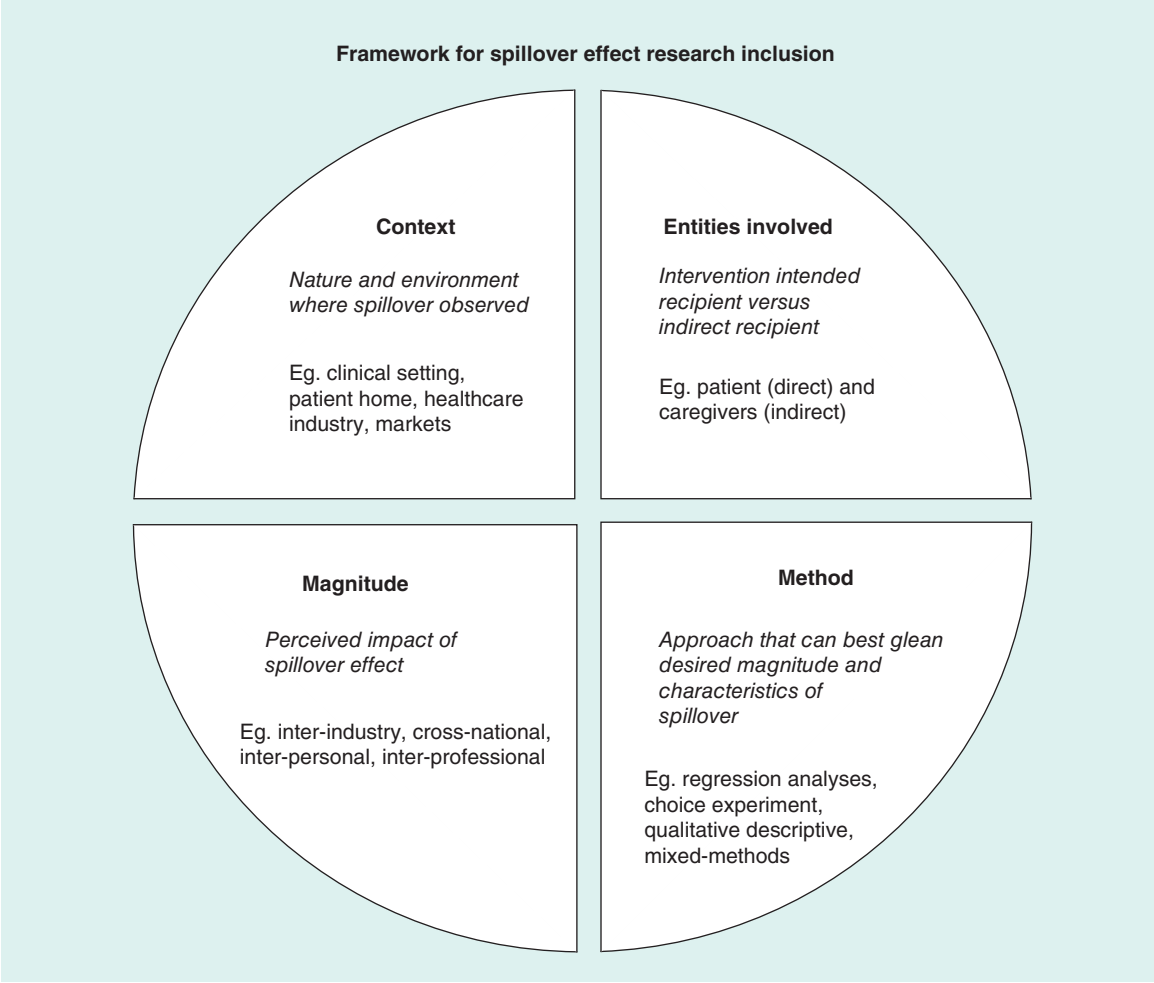

Figure 1. Framework for spillover effect research inclusion.

The highlighted factors are gleaned from the concept analysis and were developed after assessing relevant attributes, antecedents, definitions and overall characteristics of spillover effects. The first relevant factor–context describes the need to identify the environment where the spillover effect takes place. Such settings could include a hospital, a patient/family home, a healthcare corporation, or an academic evaluation of a healthcare market. The second important factor to consider is entities and domains. This factor aims to identify what/who is the entity intended to be impacted and which entity is receiving a potential spillover impact. Subsequently, the third domain is the magnitude or overall impact of spillovers. Magnitude can be considered a geographic, interpersonal or interindustry impact. Estimating the potential magnitude can aid in understanding the extent to which the spillover needs to be studied. A final consideration is the methods approach. Finally, methods selection should be guided by the contextual, entity and magnitude considerations. Such evaluation of important factors driving spillover effects, as determined from this concept analysis, can guide spillover effect integration in health economic studies.

Conclusion

This concept analysis expands definitions and characteristics of spillover effects for consideration in health economic studies. Few health economic studies to date adequately incorporate spillover effects and when incorporated, most evaluations focus on family spillovers evaluated quantitatively [20]. Spillover effects serve a role in enhancing the societal perspective of a study, given that they reveal contexts and unintended effects of a strategy or intervention on various groups or entities that have been traditionally overlooked in a traditional economic model [25,51]. This concept analysis used a multidisciplinary lens to identify defining characteristics of spillover effects to expand considerations of spillover effects for use in health economic evaluations.

Summary points

- Within health economics research, spillover effects are traditionally considered the health impacts of an intervention unintentionally imparted upon the family member of an ill individual. Broader considerations of spillover effects can enhance economic evaluations.
- A concept analysis was conducted across academic disciplines. Key attributes included: lack of intention (unintentional), positive or negative impacts and two entity/domain involvement. An initial action and targeted outcome were identified antecedents of spillover effects. Consequences varied in terms of magnitude and domain of impact across industries, life domains and interpersonal relationships.
- Expanded conceptualizations of spillover effects can strengthen economic evaluations. Economic evaluations assessing spillovers should consider the context, entities and magnitude of spillovers to inform method selection.

Author contributions

KJ Muir contributed substantially to manuscript conception and design, literature review and drafting of manuscript work. J Keim-Malpass contributed substantially to manuscript conception and design, drafting of manuscript work and revisions of drafts. Both authors agree to be accountable for all aspects of the work, inclusive of manuscript integrity.

Financial & competing interests disclosure

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

No writing assistance was utilized in the production of this manuscript.

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Exhibit Q

ANNALS, AAPSS, 455, May 1981

The Effect of Gun Availability on Violent Crime Patterns

By PHILIP J. COOK

ABSTRACT: Social scientists have started to find answers to some of the questions raised in the ongoing debate over gun control. The basic factual issue in this debate concerns the effect of gun availability on the distribution, seriousness, and number of violent crimes. Some evidence is available on each of these dimensions of the violent crime problem. The distribution of violent crimes among different types of victims is governed in part by the "vulnerability pattern" in weapon choice. The seriousness of robbery and assault incidents is influenced by weapon type, as indicated by the objective dangerousness and instrumental violence pattern. A reduction in gun availability would cause some weapon substitution and probably little change in overall robbery and assault rates—but the homicide rate would be reduced.

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THE DEBATE over the appropriate degree of governmental regulation of firearms has been a prominent feature of the political landscape for the last two decades. The claims and counterclaims for various gun control strategies have been bruited in congressional and state legislative hearings, political campaigns, editorials, and bumper strips. The issues are by this time familiar to even disinterested bystanders: the proper interpretation of the Second Amendment; the value of guns as a means of defense against burglars, or foreign invaders, or local tyrants; the difficulty of depriving criminals of guns without depriving the rest of us of basic rights; and so forth. This "great American gun war"[1] clearly involves both value questions and questions of fact, and the latter have been the subject of numerous statistical skirmishes. Strangely, however, the relevant factual questions have not attracted much attention from scholars until very recently. The role of guns—and other types of weapons—in violent crime is a fit and important subject for scientific inquiry. No etiological theory of violent crime is complete without due consideration of the technology of violent crime. This would be true even in the absence of political interest in gun control.

Each of the major categories of violent crime—criminal homicide, aggravated assault, robbery, and rape—is committed with a variety of weapons. Guns are used in a minority of violent crimes, but are of special concern because they are used in almost two thirds of the most serious events, criminal homicides, and because, unlike most other commonly used weapons (hands, kitchen knives, and baseball bats), it is conceivable that we might reduce the availability of guns without imposing unacceptable costs on the public. The principal factual question in the gun control debate is whether reducing gun availability would reduce the amount and/or seriousness of violent crime. Can potential violent criminals be deterred from obtaining guns, carrying guns, and using guns in crime? If so, will this reduction in gun use make any difference, or will criminals simply substitute other weapons to equal effect? The answers to these questions are crucial to policy evaluation. Our ability to answer these questions—to make accurate predictions about the effects of legal interventions in this area—is one measure of our scientific understanding of the role of weapons in violent crime.

At the sacrifice of some dramatic tension, I provide a preview of my results here. The type of weapon used in a violent crime is in part determined by the nature of the victim; guns are most likely to be used against the least vulnerable victims in robbery and homicide. The type of weapon used in a violent crime influences the outcome of the crime: gun robberies, when compared with other types of robbery, are more likely to be successful, less likely to result in injury to the victim, and more likely to result in the victim's death; gun assaults are more likely to result in the victim's death than knife assaults, *ceteris paribus*. A general increase in gun availability would probably have little effect on the overall robbery rate, but would increase the homicide rate, including the rate of robbery murder, and possibly reduce

1. A phrase coined by B. Bruce-Briggs, "The Great American Gun War," *The Public Interest*, 45:1–26 (fall 1976).

the number of aggravated assaults. These and other predictions emerge from the empirical results presented here. My overall conclusion is that the technology of violent crime matters a great deal in a number of dimensions, with important implications for the gun control debate.

THE BASIC ISSUES

Gun control measures come in a variety of forms, but most share the objective of reducing the availability of guns for use in violent crime. Most federal and state gun regulations in the United States are moderate interventions intended to reduce criminal use while preserving the majority's access to guns for legitimate uses.[2] Washington, D.C., and New York City have adopted a much broader attack on the handgun problem, with a ban on sales to all but a few people. Whether the regulations are moderate or extreme, some opponents of gun control insist that a regulatory approach will be ineffective in reducing criminal violence. Their position is summarized in two bumper strips: "When guns are outlawed, only outlaws will have guns," and "Guns don't kill people—people kill people." The former suggests that "outlaws" will acquire guns, despite whatever steps are taken to stop them, that is, that criminals will continue to do what is necessary to obtain guns, even if the price, hassle, and legal threats associated with obtaining a gun are increased substantially. The latter bumper strip apparently is meant to suggest that people who decide to kill will find a way even if they do not have access to guns. This is one aspect of a more general issue, the degree of "substitutibility" between guns and other weapons in homicide and other violent crimes. In short, does the type of weapon matter?

Supposing that we were somehow successful in discouraging some violent people from obtaining guns and using them in crime, how might violent crime patterns change? Three dimensions of the violent crime problem are important: (1) the *distribution* of robberies, aggravated assaults, rapes, and homicides across different types of victims, for example, commercial versus noncommercial robbery; (2) the *seriousness* of robberies, rapes, and aggravated assaults; and (3) the overall *rates* of each of these crimes. These three dimensions are considered in turn in the next three sections.[3]

DISTRIBUTION: THE VULNERABILITY PATTERN

People who attempt robbery or homicide are more likely to succeed with a gun than with other commonly used weapons. A gun is particularly valuable against victims who are physically strong, armed, or otherwise relatively invulnerable—the gun is "the great equalizer." The patterns of weapon use in criminal homicide and robbery demonstrate that perpetrators are most likely to use guns against victims who would have the best chance of defending themselves against other weapons; that is, the likelihood of a gun being chosen by a robber or killer increases with the value of a gun in effecting a successful completion of the crime. These observations suggest that a program that is successful in re-

2. For a summary of federal and state gun control measures, see my article, with James Blose, in this issue.

3. I am indebted to Mark Moore for this approach to carving up the violent crime problem. In the review that follows I omit any discussion of rape, since relevant empirical studies are lacking for this crime.

ducing the rate of gun ownership by potential robbers or killers will change the relative distribution of these crimes among different types of victims. The evidence and implications of the vulnerability pattern are presented in the following sections, beginning with criminal homicide.

Criminal homicide

A decision to kill is easier and safer to implement with a gun than with other commonly available weapons—there is less danger of effective victim resistance during the attack, and the killing can be accomplished more quickly and impersonally, with less sustained effort than is usually required with a knife or blunt object. A gun has greatest value against relatively invulnerable victims, and the vulnerability of the victim appears to be an important factor in determining the probability that a gun will be used as the murder weapon.

The least vulnerable victims are those who are guarded or armed. All presidential assassinations in U.S. history were committed with a handgun or rifle. Almost all law enforcement officers who have been murdered in recent years were shot: in 1978, 91 of 93 murdered officers were killed by guns.[4]

Physical size and strength are also components of vulnerability. In 1977, 68.5 percent of male homicide victims were shot, compared with only 51.0 percent of female homicide victims.[5] The victims' age pattern of gun use also reflects the vulnerability pattern: about 70 percent of victims aged 20–44 are shot, but this fraction drops off rapidly for younger and older—that is, more vulnerable—victims.[6]

Vulnerability is of course a relative matter. We would expect that the lethality of the murder weapons would be directly related to the difference in physical strength between the victim and killer, other things being equal. To investigate this hypothesis, I used FBI data coded from the supplemental homicide reports submitted for 1976 and 1977 by police departments in 50 large cities. These data include the demographic characteristics of the victim and, where known, the offender, as well as the murder weapon, immediate circumstances, and apparent motive of the crime. The results calculated from these data tend to confirm the relative vulnerability hypothesis. First, women tend to use more lethal weapons to kill their spouses than do men: 97 percent of the women, but only 78 percent of the men, used a gun or knife. The gun fractions in spouse killings are 67 percent and 62 percent, respectively—not a large difference, but one that is notable, since women typically have less experience than men in handling guns and are less likely to think of any guns kept in the home as their personal property. It is also true that women who kill their "boyfriends" are more likely to use a gun than men who kill their "girlfriends."

Table 1 focuses on killings resulting from arguments and brawls in which both the killer and the victim were males. The gun fraction increases with the age of the killer and is inversely related to the age

4. FBI, *Crime in the United States, 1978* (Washington, DC: U.S. Government Printing Office).

5. U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the U.S., 1978* (Washington, DC: U.S. Government Printing Office).

6. FBI.

TABLE 1

GUN USE IN MURDERS AND NONNEGLIGENT HOMICIDES RESULTING FROM ARGUMENTS OR BRAWLS, MALE VICTIM AND MALE OFFENDER

VICTIM'S AGE	OFFENDER'S AGE		
	18–39	40–59	60+
18–39 (in percentage)	68.0	79.6	87.2
N*	1906	368	47
40–59 (in percentage)	54.5	64.1	66.7
N	398	245	57
60+ (in percentage)	48.3	49.2	63.3
N	58	61	30

SOURCE: FBI Supplemental Homicide Reports, 50 large cities, 1976 and 1977 combined (unpublished).
* N = the sample size, that is, the denominator of the fraction. Cases in which the age of the killer is not known are excluded.

of the victim: the highest gun fraction—87 percent—involves elderly killers and youthful victims; the lowest gun fraction—48 percent—involves youthful killers and elderly victims. Since age is highly correlated with strength and robustness, these results offer strong support for the relative vulnerability hypothesis.

Why are less vulnerable murder victims more likely to be shot than relatively vulnerable victims? A natural interpretation of this result is that intended victims who are physically strong or armed in some fashion are better able to defend themselves against homicidal assault than more vulnerable victims—unless the assailant uses a gun, the "great equalizer." The "vulnerability pattern" can then be explained as resulting from some combination of three mechanisms. (1) Homicidal attacks are more likely to fail against strong victims than weak ones, and the difference in the likelihood of failure is greater for nongun attacks than attacks with a gun. (2) The likelihood that an individual will act on a homicidal impulse depends in part on the perceived probability of success. The intended victim's ability to defend himself acts as a deterrent to would-be killers—but this deterrent is much weaker if the killer has a gun than otherwise. (3) In the case of a planned murder, the killer will have the opportunity to equip himself with a tool that is adequate for the task. Against well-defended victims, the tool chosen will almost certainly be a gun, if one can be obtained without too much difficulty.

Each of these mechanisms is compatible with the prediction that a reduction in gun availability will cause a reduction in homicide, a reduction that will be concentrated on killings that involve a victim who is physically stronger than the killer. A number of specific hypotheses are suggested by this observation, including the following: a reduction in gun availability will reduce the male:female victimization ratio in killings of spouses and other intimates, reduce the fraction of homicide victims who are youthful males, and reduce the fraction of killers who are elderly.

Robbery

Robbery is defined as theft or attempted theft by means of force or

the threat of violence.[7] The robber's essential task is to overcome through intimidation or force the victim's natural tendency to resist parting with his valuables. A variety of techniques for accomplishing this task are used in robbery, including actual attack—as in "muggings" and "yokings"—and the threatening display of a weapon such as a gun, knife, or club. Whatever the means employed, the objective is to quickly gain the victim's compliance or to render him helpless, thereby preventing the victim from escaping, summoning help, or struggling. The amount of what could be called "power"—capability of generating lethal force—the robber needs to achieve these objectives with high probability depends on the characteristics of the robbery target—victim—and in particular on the vulnerability of the target. The most vulnerable targets are people who are young, elderly, or otherwise physically weak or disabled—for example, by alcohol—who are alone and without ready means of escape. The least vulnerable targets are commercial places, especially where there are several customers and clerks and possibly even armed guards—a bank being one extreme example.

A gun is the most effective tool for enhancing the robber's power. Unlike other common weapons, a gun gives a robber the capacity to threaten deadly harm from a distance, thus allowing him to maintain a buffer zone between himself and the victim and to control several victims simultaneously. A gun serves to preempt any rational victim's inclination to flee or resist.[8] Wesley Skogan documented the effectiveness of a gun in forestalling victim resistance in his analysis of a national sample of victim-reported robberies;[9] only 8 percent of gun robbery victims resisted physically in noncommercial robberies, compared with about 15 percent of victims in noncommercial robberies involving other weapons.[10] Other types of resistance—arguing, screaming, and fleeing—were also less common in gun robbery than in robbery involving other weapons.

It seems reasonable to assume that, from the robber's viewpoint, the value of employing a gun tends to be inversely related to the vulnerability of the target. A gun will cause a greater increase in the likeli-

7. The perspective of this section was first developed in John Conklin's seminal work on robbery in Boston: *Robbery and the Criminal Justice System* (Philadelphia: J. B. Lippincott, 1972).

8. Ibid., pp. 110–11; Conklin analyzes a gun's usefulness in terms of the ability it provides the robber to (1) maintain a buffer zone; (2) intimidate the victim; (3) make good the threat, if necessary; and (4) ensure escape.

9. Wesley Skogan, "Weapon Use in Robbery: Patterns and Policy Implications," unpublished manuscript (Northwestern University: Center for Urban Affairs, 1978). He used the robbery incident reports collected from the National Crime Panel, which occurred during calendar year 1973. It should be noted that any analysis of victim survey data relies on the victim's impression of the nature of the weapon that was employed in the robbery. In some cases the "gun" may be a toy, or simulated; Floyd Feeney and Adrianne Weir [*The Prevention and Control of Robbery: A Summary*," unpublished manuscript (University of California, Davis: Center on Admin. of Criminal Justice, 1974] report that of 58 "gun" robbers interviewed in Oakland, 3 claimed to have used toys and 4 to have simulated the possession of a gun.

10. Richard Block [*Violent Crime* (Lexington, MA: Lexington Books, 1977)] found from studying robbery police reports in Chicago that victims who resisted with physical force typically (68 percent) did so in response to the robber's use of force. Other types of resistance typically (70 percent) preceded the robber's use of force.

hood of success against well-defended targets than against more vulnerable targets. A strong-arm technique will be adequate against an elderly woman walking alone on the street—a gun would be redundant with such a victim—but a gun is virtually a requirement of successful bank robbery. Skogan provides evidence supporting this claim: he finds little relationship between robbery success rates and weapon type for personal robbery, but a very strong relationship for commercial robbery. He reports that success rates in commercial robbery were 94 percent with a gun, 65 percent with a knife, and 48 percent with other weapons.[11]

In economic terms, we can characterize robbery as a production process with weapons, robbers, and a target as "inputs."[12] The "output" of the production process can be defined as the probability of success. This probability increases with the number and skill of the robbers, the vulnerability of the target, and the lethal effect of the weapons. For given robber and target characteristics, the "marginal product" of a gun can be defined as the increase in probability of success if the robber(s) substitute a gun for, say, a knife. The evidence presented in the preceding paragraphs suggests that the marginal product of a gun is small against vulnerable targets and is relatively large against well-defended targets. We can go one step further and define the "value of a gun's marginal product" as its marginal product (increase in success probability) multiplied by the amount of loot if the robbery is successful. Since for obvious reasons, targets with greater potential loot tend to be better defended against robbery,[13] the *value* of the gun's marginal product is even more strongly related to target vulnerability than is the marginal product of the gun. The conclusion can be put in the form of a proposition:

> The economic value of a gun in robbery tends to be greatest against commercial targets and other well-defended targets, and least against highly vulnerable targets.

It makes good economic sense, then, for gun use in robbery to be closely related to target vulnerability. This is indeed the case, as demonstrated in Table 2, which is based on tabulating results of more than 12,000 robbery reports taken from victim survey data gathered in 26 large cities.

From Table 2, we see that 55 percent of gun robberies committed by adults, but only 13 percent of other adult armed robberies, involve commercial targets. Those relatively few gun robberies that were committed against people on the street are concentrated on relatively invulnerable targets—groups of two or more victims or prime-age males—while street robbery with other weapons was more likely to involve women, children, and elderly victims. Skogan

11. Skogan.

12. This perspective is further developed in Philip J. Cook, "The Effect of Gun Availability on Robbery and Robbery Murder: A Cross Section Study of Fifty Cities," in *Policy Studies Review Annual*, eds. Robert H. Haveman and B. Bruce Zellner, Vol. 3 (Beverly Hills, CA: Sage, 1979), pp. 752–53 (hereafter cited as "The Effect of Gun Availability").

13. It is obvious that commerical targets tend to be more lucrative than noncommercial and that a group of two or more victims will be more lucrative on the average than a single victim. Feeney and Weir (p. 24) report the not-so-obvious result that robberies of male victims resulted in a much higher median take ($50) than robberies of female victims (less than $20).

TABLE 2

DISTRIBUTION OF ROBBERIES (IN PERCENTAGE)

ALL ROBBERIES ACROSS LOCATIONS

	GUN	KNIFE OR OTHER WEAPON	UNARMED
Commercial	55.1	13.3	19.1
Residence	6.4	10.4	8.5
Street, vehicle, and so forth	38.5	76.3	72.4
Total	100.0	100.0	100.0

STREET ROBBERIES BY VICTIM CHARACTERISTICS

	GUN	KNIFE OR OTHER WEAPON	UNARMED
Male victim age 16–54	59.8	53.8	41.1
Two or more victims	10.5	5.8	3.7
All others (young, elderly, and/or female victim)	29.7	40.4	55.2
Total	100.0	100.0	100.0

SOURCE: Adapted from Philip J. Cook, "Reducing Injury and Death Rates in Robbery," p. 43. © 1980 by The Regents of the University of California. Reprinted from *Policy Analysis*, Volume 6, No. 1 (Winter 1980), by permission of The Regents. The distributions are calculated from National Crime Panel victimization survey data of 26 cities.

NOTE: All incidents involved at least one male robber age 18 or over. Entries in the table reflect survey sampling weights.

provides further detail for commercial robberies, reporting that the likelihood that a gun is present in such robberies is only 44 percent for commercial places that have only one employee, but 68 percent for commercial places with two or more employees.[14]

What is the causal process that produces these patterns in gun robbery? There are two plausible explanations, both compatible with the evidence presented in the preceding paragraphs: (1) robbers who aspire to well-defended, lucrative targets equip themselves with a gun in order to increase their chance of success or (2) robbers who happen to have a gun are more tempted to rob lucrative, well-defended targets than robbers who lack this tool. In short, the question is whether the weapon is chosen to suit the task or, rather, the available weapon helps define the task. There is doubtless some truth in both explanations.

The first explanation suggests that the observed relationship between gun use and target choice is the result of differences between the kinds of people that rob lucrative targets and those who commit relatively petty street robberies—a difference reminiscent of John Conklin's distinction between "professionals" and "opportunists."[15] Victim survey evidence does suggest that gun robbers as a group have more of the earmarks of professionalism than other armed robbers: besides the fact that they make bigger "scores," gun robbers are older, less likely to rob acquaintances, and less likely to work in large groups of three or more. The factors that determine a robber's choice of weapon have some tendency to persist: a cohort of adult

14. Ibid., calculated from figures in his Table 3.

15. Ibid.

men arrested for gun robbery in the District of Columbia showed a greater propensity to use guns in subsequent robberies than the corresponding cohort of nongun robbery arrestees.[16]

It seems reasonable to hypothesize, then, that robbers who engage in planning and who seek out big scores will take pains to equip themselves with the appropriate weapon—usually some type of firearm. The frequency with which other less professional robbers use guns, and hence the kinds of targets they choose, may be more sensitive to the extent to which such people have access to guns and are in the habit of carrying them, for whatever reason. Increased availability of guns may then result in some target switching by this group—substitution of more lucrative, better-defended targets for more vulnerable targets. Increased gun availability may also result in weapon substitution for a given type of target, implying an increase in the fraction of street robberies committed with a gun; that is, guns will be put to less valuable uses, as guns become "cheaper." These hypotheses can be stated more precisely as follows:

> An increase in gun availability in a city will (1) increase the fraction of noncommercial robberies commited with a gun and (2) increase the fraction of robberies committed against commercial and other well-defended targets.

In an earlier study of robbery patterns across 50 cities,[17] I found some confirmation for the first of these two predictions; controlling for other robbery-related variables, the fraction of robberies committed with a gun increases with the density of gun ownership in a city. A 10 percent increase in the fraction of households that owns guns is associated with approximately a 5 percent increase in the rate of gun robbery.

Conclusions

The preceding evidence demonstrates the existence of an important vulnerability pattern in weapon choice in homicide and robbery. Guns give assailants the power to succeed in killing or robbing relatively invulnerable victims who would have a good chance of fending off attack with a less lethal weapon. If some potential killers were deprived of guns, the criminal homicide rate would be reduced. The reduction would be concentrated among the least vulnerable types of potential victims—law enforcement officers, people with bodyguards, husbands of homicidal women, youthful men, and so forth. If robbers were deprived of guns, there would be a reduction in robberies against commercial places and other well-defended victims. In general, a reduction in gun availability would change the distribution of violent crimes, with greater concentration on vulnerable victims.

16. Philip J. Cook and Daniel Nagin, *Does the Weapon Matter?* (Washington, DC: Institute for Law and Social Research, 1979). The results cited here are based on 541 adult male gun robbery arrestees and 761 nongun robbery arrestees. This cohort, which was arrested in 1973, was tracked through 1976 through Prosecutor's Management Information System (PROMIS). The robbery re-arrest rate for the gun cohort was 43 percent, of which 58 percent were gun robberies. The robbery re-arrest rate for the nongun cohort was 45 percent, of which 40 percent were gun robberies. The two cohorts had the same re-arrest rate for burglary (13 percent), but the nongun cohort was much more likely to be re-arrested for assaultive crimes (22 percent, as opposed to 13 percent for the gun cohort); see Table 9 of Cook and Nagin.

17. Cook "The Effect of Gun Availability."

SERIOUSNESS: THE OBJECTIVE DANGEROUSNESS PATTERN

Recall that I am concerned with three dimensions of violent crime: the distribution, the seriousness, and the number of incidents. The vulnerability pattern suggests that gun availability will in certain respects influence the distribution of robberies and homicides across different categories of victims. I now turn to the seriousness dimension of violent crime. "Seriousness" in this discussion will be defined as the degree of injury to the victim. A violent or potentially violent confrontation, as in robbery, rape, or assault, can result in a range of possible outcomes, from no physical harm up to serious injury or death of the victim. The likelihood that the victim will be killed is influenced by the lethal effects of the weapon used by the perpetrator. The evidence on this "objective dangerousness" pattern is presented first for serious assaults, and subsequently for robbery.

Serious assaults

The fraction of serious gun assaults that result in the victim's death is much higher than for assaults with other weapons. Richard Block, for example, found that of all aggravated assaults resulting in injury to the victim—and reported to the Chicago Police—14 percent of the gun cases, but only 4 percent of the knife cases, resulted in the victim's death.[18] In part, this difference is the result of differences between gun and knife attacks in intent and capability. An assailant who intends to kill his victim, and who has some chance to prepare, is more likely to equip himself with a gun than an assailant who merely intends to hurt his victim. Furthermore, an attack that is intended to kill is more likely to be successful if perpetrated with a gun than with a knife or other weapon—especially against victims who are capable of defending themselves. But differences in intent and capability are not the whole story.

Franklin Zimring has demonstrated that a large proportion of murders are similar to serious assaults in that the attacks are unsustained[19]—the assailant does not administer the coup de grace, the blow that would ensure the death of his victim. Indeed, the victim was shot only once in about two thirds of the gun homicides in Zimring's Chicago samples. These cases differ very little from serious assaults: for every death resulting from a single wound in the head or chest, Zimring found 1.8 victims with the same type of wound who did not die[20]—victims who were clearly not saved by any differences in the gunman's intent or capability, but rather just by good luck with respect to the precise location of the wound.

Evidently, some proportion of gun murders are not the result of a clear intent to kill; given that the majority of murders are the immediate result of altercations, often involving alcohol and rarely much thought, it seems unlikely that many killers have any clearly formulated "intent" at the time of their attack. The assailant's mental state is characterized by an impulse—to punish, avenge an insult, or stop a verbal or physical attack—backed by more or less

18. Ibid., p. 33

19. Franklin Zimring, "The Medium is the Message: Firearm Calibre as a Determinant of Death from Assault," *J. Legal Studies*, I(1): 97–124 (Jan. 1972); and idem, "Is Gun Control Likely to Reduce Violent Killings?" *Univ. Chicago Law Review*, 35:721–37 (1967).

20. Ibid., computed from Table 7, p. 104.

cathexis. The immediate availability of a gun makes these circumstances more dangerous than would a less lethal weapon because an unsustained attack with a gun—a single shot—is more likely to kill than an unsustained attack with another weapon.

Zimring buttressed the conclusions from his first study, which compared knife and gun attacks, with a later study comparing large and small caliber gun attacks. Even after controlling for the number and location of wounds, he found that .38 caliber attacks were more than twice as likely to kill as .22 caliber attacks.[21] It appears, then, that weapon dangerousness has a substantial independent impact on the death rate from serious assaults.

Zimring's seminal work in this area supports several important propositions, including:

1. A restrictive gun control policy that causes knives and clubs to be substituted for guns will reduce the death rate in serious assault.

2. A gun control policy that focuses on handguns may increase the death rate from gun assault if shotguns and rifles are substituted for handguns as a result.[22]

3. In setting prosecution and sentencing priorities for aggravated assault cases, gun assaults should be viewed as more serious than assaults with other weapons, *ceteris paribus*, since there is a higher probability of the victim's dying in the gun assaults. This is Zimring's "objective dangerousness" doctrine.[23]

21. Ibid., 1972.

22. This implication has been pointed out by Gary Kleck, "The Assumptions of Gun Control" (Florida State University, 1980) (unpublished).

23. "In the generality of cases, how likely is it that conduct such as that engaged in by the offender will lead to death?" Zimring, p. 114.

Richard Block extended Zimring's work on instrumentality by comparing death rates in aggravated assault and robbery cases. He concludes that "the relative fatality of different weapons in violent crime may be a technological invariant— . . . the probability of death given injury and a particular weapon remains relatively constant and unrelated to the type of crime committed."[24]

The notion that the number of deaths per 100 injuries is a "technical" constant, largely determined by the lethality of the weapon, is not supportable, however. Zimring demonstrated that the type of weapon was one important determinant of the outcome of serious attacks, but did not claim it was the only determinant. Presumably the weapon-specific death rates in such attacks will differ across jurisdictions and vary over time depending on the mix of circumstances, the quality of medical care, and so forth. Arthur Swersey presents an interesting case in point.[25]

Swersey reports that the number of assaultive—as opposed to felony—gun homicides in Harlem increased from 19 in 1968 to 70 in 1973, and then fell back to 46 in 1974. Much of the change between 1968 and 1973 was from an increase in intentional killings resulting from disputes involving narcotics activities. The importance of changes in the intent of violent perpetrators during this period is indicated by the fact that the death rate in gun attacks doubled between 1968 and 1973, and then fell back in 1974. Swersey concludes that more than 80 percent

24. Block, p. 32.

25. "A Greater Intent to Kill: The Changing Pattern of Homicide in Harlem and New York City" (Yale School of Organization and Management, 1980) (unpublished).

TABLE 3

LIKELIHOOD OF PHYSICAL ATTACK AND INJURY IN ROBBERY (IN PERCENTAGE)

	GUN*	KNIFE†	OTHER WEAPON	UNARMED
Noncommercial robbery**				
Victim attacked	22.1	39.4	60.4	73.5
Victim required medical treatment†	7.2	10.9	15.5	11.1
Victim hospitalized overnight	2.0	2.6	2.7	1.6
Number of cases (not in percentage)	892	841	1060	1259
Commercial robbery				
Victim required medical treatment	4.8	10.8	17.9	5.1
Victim hospitalized overnight	1.5	3.5	6.0	0.4
Number of cases (not in percentage)	2307	288	117	570

SOURCE: National Crime Panel victimization surveys of 26 cities. This table is excerpted from Philip J. Cook, "Reducing Injury and Death Rates in Robbery," Table 2. © 1980 by The Regents of the University of California. Reprinted from *Policy Analysis*, Volume 6, No. 1 (Winter 1980), by permission of The Regents.

NOTE: All incidents included in this table involved at least one male robber age 18 or over. Entries in the table do not reflect the survey sampling weights, which differed widely among the 26 cities.

* Many robberies involve more than one type of weapon. Incidents of that sort were classified according to the most lethal weapon used.

** Robberies occurring on the street, in a vehicle, or near the victim's home.

† Only about one third of the injured gun robbery victims were actually shot. Two thirds of the injured knife robbery victims were stabbed.

of the rise and fall in Harlem homicides was due to changes in the number of deliberate murders. He finds a similar pattern for the rest of New York City.[26]

Swersey's findings do not undermine Zimring's position. Zimring did not deny that some killings were unambiguously motivated, or that the importance of intent in murder was subject to change over time, or that it might be more important in Harlem than in Chicago. In any event, Swersey's results are useful in documenting these possibilities.

My conclusions can be briefly stated. The likelihood of death from a serious assault is determined, *inter alia*, by the assailant's intent and the lethal nature of the weapon he uses. The type of weapon is especially important when the intent is ambiguous. The fraction of homicides that can be viewed as deliberate—unambiguously intended—varies over time and space, but is probably fairly small as a rule. The fraction of gun assaults that results in the death of the victim is one indication of the relative prevalence of deliberate gun murders.

26. Swersey also notes several other indications of an increasing fraction of deliberate murders in the homicide statistics for New York City as a whole. During the 1970s, the clearance rate declined for homicide, as did the fraction of homicides occurring on the weekend and the fraction involving family members.

Robbery

The principal role of a weapon in robbery is to aid the robber in coercing the victim—either by force or threat—to part with his valuables. If the threat is sufficiently convincing, physical force is not necessary. For this reason, it is hardly surprising that the use of force is closely related to the weapon type in robbery, being very common in unarmed robbery and rare in gun robbery. Table 3 documents this pattern for both commercial and noncommercial robberies committed by adult males. As shown in this table, gun robberies are less likely than other armed robberies to involve

physical violence and, furthermore, are less likely to injure the victim.[27] These patterns are compatible with the notion that violence plays an instrumental role in robbery—that it is employed when the robber believes it is needed to overcome or forestall victim resistance and that this need is less likely to arise when the robber uses a gun than otherwise.

There is evidence, however, that this "instrumental violence" pattern can account for only a fraction of the injuries and deaths that result from robbery. Three observations are relevant in this respect. First, over two thirds of victims injured in noncommercial gun robberies do not resist in any way—even after the attack;[28] similarly, 20 out of 30 victims killed in gun robberies in Dade County between 1974 and 1976 did not resist the robber. Second, the likelihood that the victim will be injured in an armed robbery is much higher if the robbery is committed by a gang of three or more than otherwise; since victims are less likely to offer resistance to a group of three or four robbers than to a lone robber, this result is clearly incompatible with the "instrumental violence" hypothesis. Third, judging from re-arrest statistics for a large cohort of adult robbery arrestees in Washington, D.C., it appears that robbers who injure their victims tend to be more violence prone than other robbers.[29]

These findings are different aspects of an "excess violence" pattern: much of the violence in robbery is not "necessary," in the sense of being an instrumental response to anticipated or actual resistance by the victim. Rather, it is motivated by objectives or impulses that have little to do with ensuring successful completion of the theft. In particular, the high incidence of violence in street robberies committed by larger groups—which typically have a low "take"—is best viewed as a form of recreation, and the gratuitous violence against the victim may be just part of the fun.

Given these findings, it is useful to attempt a distinction between "robbery with intent to injure" or kill and robbery without such intent—in which violence would only be used to overcome victim resistance. The latter form of robbery dominates the statistics—most victims are not in fact injured, and the likelihood of injury is less with guns than with other weapons. However, the more violent strain of robbery, involving an intent to injure, apparently accounts for a high percentage of the serious injuries and deaths that do occur in the robbery context. Furthermore, the incidence of excess violence in robbery is subject to change over time, as Zimring demonstrated in his study of robbery murder in Detroit.[30] He found a sharp discontinuity in 1972 in the fraction of victims killed in armed robbery: after 10 years of stable weapon-specific death rates, this fraction doubled between 1971 and 1973 for gun robberies and increased even more during this period for other armed robberies.

27. Other sources on this pattern include Conklin; Skogan; and Philip J. Cook, "A Strategic Choice Analysis of Robbery" in *Sample Surveys of the Victims of Crimes*, ed. Wesley Skogan (Cambridge, MA: Ballinger, 1976) (hereafter cited as "A Strategic Choice Analysis of Robbery").

28. Philip J. Cook, "Policies to Reduce Injury and Death Rates in Robbery," *Policy Analysis*, 6(1):36 (winter 1980) (hereafter cited as "Policies to Reduce Injury and Death Rates").

29. Cook and Nagin, p. 39.

30. Franklin Zimring, "Determinants of the Death Rate from Robbery: A Detroit Time Study," *J. Legal Studies*, 6(2):317–32 (June 1977).

Are gun robberies more dangerous than other armed robberies, in the sense of being more likely to result in the victim's death? Victims are killed in a higher fraction of gun robberies than others: based on victim surveys and homicide data in eight cities, I calculated that there are 9.0 victim fatalities for every 1000 gun robberies, compared with 1.7 victim fatalities per 1000 nongun armed robberies.[31] Furthermore, it appears that the type of weapon plays an independent role in determining the likelihood of robbery murder; in a cross-sectional analysis of 50 cities, I found that the fraction of robberies resulting in the victim's death is closely related to the fraction of robberies that involve firearms.[32] Thus the objective dangerousness pattern applies to robbery as well as assault, for reasons that remain a bit obscure.

Why does the presence of a loaded, authentic gun in robbery increase the probability of the victim's death? My studies of robbery murder in Atlanta and Dade County[33] indicated that in at least half of the cases the killing was deliberate: for example, the victim was tied and then executed, or shot several times from close range. But insofar as intent could be ascertained from police reports, it appears that these intentional killings were not premeditated, but rather decided on during the course of the robbery. Perhaps the explanation for why these spontaneous decisions are more likely to occur when the robber is holding a gun is related to Marvin Wolfgang's suggestion: "The offender's physical repugnance to engaging in direct physical assault by cutting or stabbing his adversary, may mean that in the absence of a firearm no homicide occurs."[34]

Two conclusions can be inferred from the preceding discussion:

1. A reduction in gun availability will increase the robbery injury rate,[35] but reduce the robbery murder rate.

2. Given the excess violence pattern in robbery, the robbery cases in which the victim is injured should be allocated special emphasis in establishing criminal prosecution and sentencing priorities.[36] In a high proportion of these crimes, the attack that caused the injury was not instrumental to the robbery, but

31. Cook, "Policies to Reduce Injury and Death Rates," p. 39.

32. Cook, "The Effect of Gun Availability," p. 775. The regression equation is as follows:

$$\frac{\text{Robbery murders}}{\text{1000 robberies}} = \underset{(1.16)}{1.52} + \underset{(2.38)}{5.68}\,\frac{\text{Gun robberies}}{\text{Robberies}}$$

A closely related result uses the per capita, rather than "per robbery," murder rate:

$$\frac{\text{Rob. murders}}{\text{100,000}} = \underset{(.232)}{-.284} + \underset{(.089)}{.907}\,\frac{\text{Gun robs.}}{\text{1000}} + \underset{(.072)}{.136}\,\frac{\text{Nongun robs.}}{\text{1000}}.$$

(Numbers in parentheses are the standard errors of the ordinary least squares regression coefficients.) The data for 50 cities are 1975–76 averages. The second equation has an $R^2 = .82$, suggesting that robbery murder is very closely linked to robbery. Inclusion of the assaultive murder rate in this equation as an independent variable does not affect the other coefficients much—and the coefficient on the murder variable is not statistically significant. I conclude that robbery murder is more robbery than murder.

33. Cook, "Policies to Reduce Injury and Death Rates."

34. Marvin Wolfgang, *Patterns in Criminal Homicide* (Philadelphia: University of Pennsylvania, 1958), p. 79.

35. See Skogan.

36. Cook, "Policies to Reduce Injury and Death Rates."

rather was a distinct act. A relatively severe judicial response to such cases might act as a deterrent to excess violence in robbery.

Coercion and assault

Does the instrumental violence pattern in robbery have any parallel in assault? I suspect the answer is yes, but I know of no empirical evidence.

Some unknown fraction of assault cases are similar to robbery in that the assailant's objective is to coerce the victim's compliance—the assailant wants the victim to stop attacking him, physically or verbally, or stop dancing with his girlfriend, or get off his favorite barstool, or turn down the stereo. And, as in the case of robbery, the probability of a physical attack in such cases may be less if the assailant has a gun than otherwise because the victim will be less inclined to ignore or resist a threat enforced by the display of a gun. It may also be true that the assailant would be more hesitant to use a gun than another weapon to make good his threat. If this reasoning is correct, than a general increase in gun availability may reduce the number of assault-related injuries.

INCIDENCE: THE SUBSTITUTION PATTERN

The preceding evidence suggests that gun availability has a substantial effect on the distribution and seriousness of violent crime. The third dimension of the violent crime problem is incidence—the number of violent confrontations and attacks. For each of the crimes under consideration—assault, robbery, and homicide—a reduction in gun availability to criminals would presumably cause a reduction in the number of incidents involving guns. But for each crime there is a real possibility that the number of incidents involving weapons other than guns would increase as a result of the reduction in gun availability. If this weapon substitution does occur, the net effect of reduced gun availability on crime rates could be either positive or negative.

First, consider the crime of assault. In an environment in which a high percentage of the violence-prone people carry guns, it is possible that a sort of mutual deterrent is created, whereby a rational person would think twice before picking a fight. A protagonist that is foolish enough to start a fight in such an environment may be persuaded to back off if his intended victim pulls a gun. When physical attacks do occur, they are likely to be perpetrated with a gun and to be serious. This line of argument may explain why the Bartley-Fox Amendment in Massachusetts—an anticarrying law that was apparently quite effective—may have resulted in an increase in the rate of aggravated assaults—the gun assault rate went down substantially following implementation, but the nongun assault rate increased even more.[37] A legal intervention that is successful in getting guns off the streets may encourage relatively harmless fights with fists and broken bottles. Definitive results in this area are hard to come by, in part due to the difficulty in measuring the assault rate in a consistent manner over time or across jurisdictions.

My cross-sectional analysis of robbery in 50 cities found that one measure of gun availability—the

37. Glenn L. Pierce and William J. Bowers, "The Impact of the Bartley-Fox Gun Law on Crime in Massachusetts," unpublished manuscript (Northeastern University: Center for Applied Social Research, 1979).

density of gun ownership—was statistically unrelated to the overall robbery rate when other causal factors were taken into account.[38] By way of illustration, the two cities with the highest robbery rates—Detroit and Boston—differed markedly in gun ownership. Boston was one of the lowest, and Detroit was above average. The same study demonstrated that the fraction of robberies committed with a gun was closely related to the density of gun ownership in the city. Apparently robbers tend to substitute guns for other weapons as guns become readily available, but with little or no change in their rate of commission.

If guns were less widely available, the criminal homicide rate would fall. This prediction is justified by three distinct arguments developed in this article: (1) knives and clubs are not close substitutes for guns for implementing a decision to kill, especially when the intended victim is relatively invulnerable; (2) Zimring's "objective dangerousness" results demonstrate that a reduction in gun use in serious—but ambiguously motivated—assaults will reduce the homicide rate, and (3) my results on robbery murder in the 50-cities study indicate that the fraction of robberies that result in the victim's death is closely related to the fraction of robberies involving guns. A final bit of evidence comes from evaluations of the Bartley-Fox Amendment, which suggest that it reduced the criminal homicide rate in Massachusetts.[39] The tough new handgun law in the District of Columbia has also apparently been effective in this regard.[40] It should be noted that a crackdown focused on the least lethal type of gun—small caliber handguns—might not have the desired effect on criminal homicide if perpetrators substituted large caliber handguns or longguns.

My conclusion is that effective gun control measures are unlikely to reduce the total number of violent confrontations and attacks, but may well reduce the criminal homicide rate.

CONCLUSIONS

The type of weapon matters in violent crime, both in terms of its seriousness and its distribution. If robbers could be deprived of guns, the robbery murder rate would fall, the robbery injury rate would rise, and robberies would be redistributed to some extent from less to more vulnerable targets. The assaultive murder rate would decline, with the greatest reductions involving the least vulnerable victims. The overall assault rate might well increase. These predictions are based on common sense and a variety of empirical observations. None of this evidence is conclusive, but it is the best that is currently available.

Is it reasonable to suppose that moderate gun control measures have the potential to discourage some violent criminals—potential or active—from obtaining guns? No doubt there are some active criminals and other violence-prone people who have the incentive and resources required to acquire a gun even in the face of substantial legal barriers. But such determined people do not figure importantly in the violent crime statistics—indeed, most assaults and robberies do not even involve guns now, despite the fact that guns are readily available in most

38. Cook, "The Effect of Gun Availability."
39. See the article by Pierce and Bowers in this issue.
40. See Jones's article in this issue.

jurisdictions. A gun control measure that increases the average cost and hassle of a youthful urban male acquiring his first handgun may at least delay acquisition for a year or two—with noticeable effect on the gun crime rate. A vigorous crackdown on carrying concealed weapons may have a similar beneficial effect.

Not all of the predicted effects on violent crime of a reduction in gun availability are attractive. None of these predictions can be made with a high degree of certainty. But it is not unreasonable to suggest that a moderate, vigorously enforced program for regulating the sale and use of guns would save a substantial number of lives. Gun control is not "the solution" to America's violent crime problem, but perhaps it should be one aspect of the effort to find a solution.

Exhibit R

ANNUAL REVIEWS

Annual Review of Criminology

Firearm Instrumentality: Do Guns Make Violent Situations More Lethal?

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Annu. Rev. Criminol. 2021. 4:147–64

First published as a Review in Advance on September 14, 2020

The *Annual Review of Criminology* is online at criminol.annualreviews.org

https://doi.org/10.1146/annurev-criminol-061020-021528

Keywords

firearm, gun, gun policy, gun violence, firearm instrumentality, homicide

Abstract

One of the central debates animating the interpretation of gun research for public policy is the question of whether the presence of firearms independently makes violent situations more lethal, known as an instrumentality effect, or whether determined offenders will simply substitute other weapons to affect fatalities in the absence of guns. The latter position assumes sufficient intentionality among homicide assailants to kill their victims, irrespective of the tools available to do so. Studies on the lethality of guns, the likelihood of injury by weapon type, offender intent, and firearm availability provide considerable evidence that guns contribute to fatalities that would otherwise have been nonfatal assaults. The increasing lethality of guns, based on size and technology, and identifiable gaps in existing gun control policies mean that new and innovative policy interventions are required to reduce firearm fatalities and to alleviate the substantial economic and social costs associated with gun violence.

INTRODUCTION

Weapon instrumentality is based on the straightforward idea that the type of weapon deployed in an assault influences the mortality of the victim. Logically, guns are regarded as more lethal instruments than knives, knives more lethal than blunt instruments, and so on. Yet the National Rifle Association and other progun activists often invoke the familiar slogan "guns don't kill people, people kill people" to support their arguments for more-permissive gun controls (Henigan 2016). This perspective suggests that an attacker who has a very strong determination to kill will take the necessary steps to be successful regardless of available weapons (Cook 1991, Cook et al. 2011). As such, the assailant's will to kill is reliably measured by whether the victim survives or perishes (Braga & Cook 2018, Zimring 1972). This perspective is reified in criminal law, wherein murderers are subjected to the harshest sanctions, including life without the possibility of parole or even death (Vernick & Hepburn 2003). The "people kill people" perspective further suggests that gun control is futile in reducing homicides because determined killers will simply find another way (Kleck 1997, Wolfgang 1958, Wright et al. 1983). If guns are not available, assailants will substitute knives, blunt instruments, or other means.

The alternate view is that "guns do kill people" and gun control advocates suggest that reducing firearm availability to violent people will save lives even if determined killers select other weapons instead (Cook 1991, Cook et al. 2011, Henigan 2016). Injuries in assaultive violence are often inflicted by whatever means are most available to the attacker, most commonly fists or feet followed by other objects that are close at hand (Hedeboe et al. 1985). Although a person who is determined to kill will sometimes acquire a lethal weapon, gun-inflicted deaths often ensue from varying kinds of impromptu arguments or fights (Spitzer 1995, Zimring & Hawkins 1997). Gun control advocates suggest that many of these deaths would be replaced by nonfatal injuries if guns were not available; in essence, they suggest that a more refined slogan would be "people without guns injure people; guns kill them" (Baker 1985, p. 588).

The purported strong will to kill as the key determinant of mortality is challenged by the noteworthy similarity in the characteristics and circumstances of fatal and nonfatal gun-assault incidents (Cook et al. 2019). Mortality in many gun attacks seems to be influenced by chance events, such as the number and placement of wounds, the availability and quality of medical help, and other factors (Braga & Cook 2018). The considerable overlap between fatal and nonfatal shootings is well captured by the observation of a Boston police investigator that the difference between the two events "is often only a matter of inches and luck—a lot of times a nonfatal shooting is just a failed homicide" (Braga et al. 2014, p. 119). In her in-depth examination of South Los Angeles homicides, investigative reporter Jill Leovy (2015, p. 49) notes that there were approximately five nonfatal injury shootings for every one gun homicide and, given the similarity between the events, detectives called these nonfatal shootings "*almoscides*, for 'almost homicides.'" Research on fatal and nonfatal gun assaults further suggests that mortality is influenced by the type of gun used in the attack, and the selection of the gun in these events is largely independent of other indicators of the assailant's intent (Braga & Cook 2018, Zimring 1972). As such, the types of guns deployed in assaults dramatically influence whether the intended victim lives or dies beyond the determination of the assailant to commit murder.

Firearm instrumentality is controversial among academics who study gun control policy issues. The controversy stems from disagreement over an assailant's purported intention to kill and whether a would-be killer would merely substitute other means to complete the act if guns were not available. In their recent survey of gun policy experts, the RAND Corporation discovered two distinct groups of scholars: those who favored more-restrictive gun regulations and those who favored more-permissive gun regulations (Morral et al. 2018). According to this research, "a

striking result of the survey concerns the wide disparity between estimates made by the two expert groups about means substitution. . . . That is, they disagree about the extent to which any reductions of firearm. . .homicides attributable to a policy are undermined because individuals simply use other means to achieve those ends" (Morral et al. 2018, p. xii). The average survey participant who favored more-permissive gun controls responded that if a policy successfully reduced a state's firearm homicides, 90% of the prevented homicides would still end as a homicide by some other means. In contrast, the average survey participant who preferred more-restrictive gun controls indicated that only 20% would still end in homicide. As such, gun policy experts with preferences for more-permissive gun regulations view legislative efforts to reduce gun homicides as futile since they believe would-be killers will complete their murderous acts through other means.

Firearm instrumentality is clearly a foundational issue in the great American gun control debate. Broader arguments that seek to limit the availability of guns to violence-prone individuals through the adoption of more-restrictive gun controls are based on the idea that lives would ultimately be saved (Cook et al. 2011). In this review, we examine the available scientific evidence on whether guns make situations more lethal. The review begins by examining extensive research on the lethality of gun assaults, focusing on a range of studies that attempt to determine the existence of instrumentality effects in violent gun and non-gun crimes. Extended coverage is given to two comprehensive studies that estimate whether gun caliber, killer intent, and other chance elements in gun assaults determine the likelihood of death for victims. We find strong support for gun instrumentality effects in our review of the literature. The final sections consider the policy implications of these findings and offer recommendations for further research in this area.

THE LETHALITY OF GUNS

Guns are obviously designed to be lethal instruments. And although guns in civilian hands are used for sport shooting, hunting, and dealing with animal pests, they can also be deployed against people for legal self-defense or criminal purposes. In 2018, guns were used in more than 10,000 murders, 38,000 rapes/sexual assaults, 42,000 aggravated assaults with injury, and 96,000 robberies (Bur. Justice Stat. 2019, FBI 2018). However, it is important to note that most serious violent crime victimizations do not involve guns. The 2018 US Bureau of Justice Statistics National Crime Victimization Survey (NCVS) reveals that only 5% of rapes/sexual assault, 11% of aggravated assault with injury, and 17% of robbery victimization incidents involved a firearm (**Figure 1**). When used in violent crime, guns are usually not fired; more than three-quarters of nonfatal gun crime victims do not suffer gunshot wounds (Planty & Truman 2013). Instead, as is discussed further below, guns are typically deployed by criminals to gain compliance or threaten victims rather than to injure them. Most gun crimes involve handguns, which are used in roughly two-thirds of gun homicides and 90% of nonfatal gun violence (Planty & Truman 2013).

Among those violent gun incidents that do generate injuries, whether the victim lives or dies is often dependent upon the technology (i.e., type and characteristics) of the guns used in the assaults (for an excellent overview from a public health perspective, see Karlson & Hargarten 1997). The kinetic energy of a bullet is determined by its mass and velocity when fired from a gun. In general, the larger the caliber, the more mass the bullet will have. Larger-caliber bullets (such as .40, .44, and .45) generate more tissue damage than smaller-caliber bullets (such as .22, .25, and .32) when they strike the same body parts (Hargarten et al. 1996). Jacketed bullets tend to cause perforating wounds with less tissue damage relative to bullets designed to fragment and/or mushroom (Fackler et al. 1988). Cartridge cases can vary in the amount of explosive gun powder they hold, with larger cartridges generating higher bullet velocities when fired. Rifles are considered more lethal than handguns given the higher bullet velocities generated by the larger cartridges and the increased

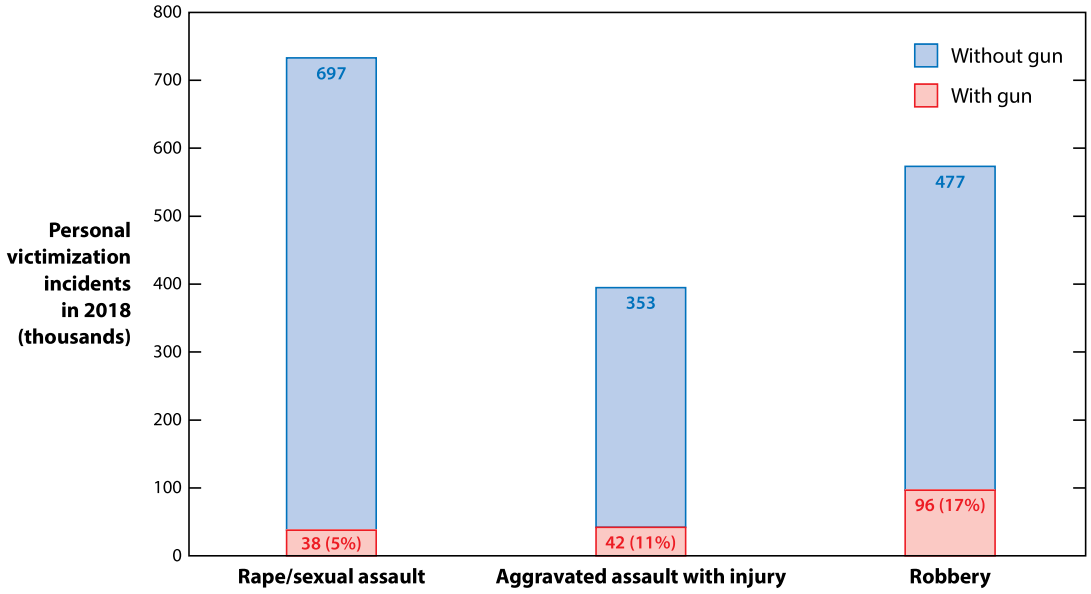

Figure 1

Personal violent victimization with and without guns, 2018. Data taken from Bureau of Justice Statistics (2019).

accuracy of the longer barrel lengths (which also contribute to increased bullet velocity). Shotguns generally fire shells filled with multiple small pellets (gauges represent pellet sizes with 10 and 12 gauge being the most common; shotguns can also fire a single rifled "slug") that can be quite lethal at close range because of the extensive tissue damage generated by a concentration of pellets and much less lethal at distance because of the dispersion of pellets after firing (Karlson & Hargarten 1997).

The number and location of gunshot wounds also influence the mortality of the victim in gun-assault incidents. Holding other factors constant, injuries to the head and upper spinal cord are considered the most lethal gunshot wounds followed by injuries to the chest and abdomen (depending on whether vital organs are hit) and to extremities such as arms and legs (Karlson & Hargarten 1997, Kellermann et al. 1991). The number of gunshot wounds involved in a gun assault also elevates victim mortality, as each wound represents additional traumatic tissue injury (D'Alessio 1999, Hargarten et al. 1996). Other factors, such as the availability of quality trauma care to save injured victims (Coupet et al. 2019) and the speed at which first responders locate gunshot victims also influence the lethality of gun attacks. By one estimate, almost three-fourths of gun homicide victims die before they reach the hospital (Karlson & Hargarten 1997).

Empirical evidence suggests that guns are becoming more lethal over time with larger shares featuring higher-capacity magazines and using larger-caliber bullets (D'Alessio 1999, Kellermann et al. 1991, McGonigal et al. 1993, Webster et al. 1992, Wintemute 1996). For instance, in Boston, higher-capacity semiautomatic pistols capable of shooting more bullets replaced revolvers as the most frequently recovered type of handgun beginning in the 1990s (Braga 2017). As a consequence, the share of smaller-caliber handguns among crime gun recoveries decreased over the 2000s as the prominence of larger-caliber handguns increased. According to **Table 1**, the share of semiautomatic pistols recovered by the Boston Police Department increased from only 34.6% of total handguns recovered between 1981 and 1985 to a peak of 75.7% between 2001 and 2005, before dropping to 66.6% between 2011 and 2015. **Table 1** shows that large-caliber handguns

Table 1 Types and calibers of recovered handguns in Boston, 1981–2015

Period	*N*	Percent semiauto	Percent .22, .25, .32	Percent .38, .357	Percent .380, 9mm	Percent .40, .44, .45
1981–1985	3,134	34.6	44.9	38.6	7.5	4.3
1986–1990	3,114	41.6	44.2	33.2	14	5.1
1991–1995	3,449	60.9	38.3	23.3	30.2	4.8
1996–2000	2,008	74.2	38.9	23.9	27.5	6.8
2001–2005	2,905	75.7	29.2	20.9	29.7	12.9
2006–2010	2,195	65.7	26.4	20.6	33.4	18
2011–2015	2,352	66.6	26.7	20.7	31.7	19.9

Table adapted from Braga (2017).

(.40, .44, and .45) increased almost fivefold from 4.3% of total handguns recovered between 1981 and 1985 to almost 20% of total handguns recovered between 2011 and 2015. Equally important, **Table 1** also documents the noteworthy shift away from medium-caliber bullets often used in revolvers (.38, .357) toward medium-caliber bullets typically used in semiautomatic pistols (.380, 9mm). The transition from revolvers to semiautomatic pistols and from smaller to larger-caliber handguns mirrors national trends in handgun production in the United States between the 1980s and 1990s (Wintemute 2010).

The increased killing power of handguns recovered by law enforcement agencies in the United States seems to have increased the lethality and number of wounds that gunshot victims experience over time. In epidemiology, the case-fatality rate is generally defined as the proportion of deaths (i.e., gun homicides) within a designated population of cases (total gunshot injury victims) (see Efron et al. 2006). For gun-assault victimizations, the case-fatality rate is roughly 1 in 6, wherein approximately 17% of gun-assault victims with injuries die from their wounds (Cook 1985). Furthermore, this rate has remained fairly stable since the 1980s, leading Cook and colleagues (2017) to conclude that national declines in gun homicide rates were better explained by decreases in the number of gun assaults rather than improvements in trauma care for firearm injuries. City-level studies, however, show that local case-fatality rates can diverge markedly from national trends and these differing patterns may be linked to changes in the technology of guns used in assaults. For instance, an analysis of gunshot wound patients treated in a Denver trauma center between 2000 and 2013 suggests that case-fatality rates increased over time as gunshot patients suffered more severe wounds and an increased number of serious wounds per patient (Sauaia et al. 2016). A similar study of 6,322 gunshot wound patients treated at the New Jersey Trauma Center at University Hospital in Newark reported significant increases in patients with three or more wounds from 13% to 22%, with a corresponding increase in mortality from 9% to 14%, between 2000 and 2011 (Livingston et al. 2014).

Criminological studies have shown that case-fatality rates can vary over the course of gun violence epidemics. For instance, in a classic study of the influence of the heroin epidemic on serious violence in New York City, the RAND Corporation found that the rapid increase in homicide in Harlem between 1968 and 1974 was driven by an increase in the case-fatality rate of gun assaults rather than an increase in the number of gun assaults (Swersey & Enloe 1975). More recently, Braga (2003) analyzed youth gun assaults in one police district located in a mostly black disadvantaged neighborhood in Boston between 1987 and 1995, representing the years before and during a gun violence epidemic initiated by the emergence of crack cocaine in the city. He found that the nature of youth gun assaults changed over time in several noteworthy ways: Larger-caliber semiautomatic pistols were more likely to be fired in gun attacks, incidents were likely to occur in public

places, a larger share of youth gun assaults resulted in a wound, and, for those assaults that involved a wound, a larger share involved multiple gunshot injuries. Most importantly, although the absolute number of youth gun assaults in 1995 was essentially the same as 1987, the case-fatality rate in this high-risk policing district tripled over the study period. Braga (2003) identified changes in both firearm instrumentality effects, as indicated by increased use of more powerful handguns with higher-capacity magazines, and shooters' intent to kill, as indicated by the increased number of wounds on youth gun-assault victims.

The empirical evidence reviewed above shows that there are several factors associated with the lethality of guns deployed in criminal assaults. In sum, it is not controversial in public health and medical research that mortality increases with the power of the gun deployed in assaults. As such, this research suggests the existence of firearm instrumentality effects. However, some observers argue that the selection of the firearm used in gun attacks is simply a reflection of the shooters' intent to kill and determined killers will complete their acts by substituting other deadly means if guns are unavailable. The next section considers findings of the criminological research on firearm instrumentality, intentionality, and the lethality of possible weapon substitution effects.

Intention Versus Instrumentality

There is considerable evidence that the risk of death is elevated when a violent incident involves a gun. In particular, Cook (2018) found that crime victims who suffered gunshot wounds were more than seven times as likely to die when compared to knife attack victims who were seriously injured. In the case of robbery, the greatest difference between fatal and nonfatal robberies was the perpetrator's choice of weapon, wherein the likelihood of victim death in gun robberies (0.41% or approximately 1 in 250) was three times higher than knife robberies (0.13% or approximately 1 in 750) and 10 times higher than robberies committed with other weapons (0.04% or approximately 1 in 2,500), such as blunt instruments (Cook 1987). The likelihood of death in an unarmed robbery was approximately 1 in 5,000 (or 0.02%). Given that only 17% of total robberies involve firearms, but 65% of robbery murders are committed with a gun, the choice of weapon appears to have a significant and independent effect on the likelihood of victim fatality (Cook 1987). Cook (1987) found further evidence of firearm instrumentality effects in his panel analysis of changes in crime rates across 43 US cities; in this case, an additional 100 gun robberies increased the robbery-murder rate by three times as much as an additional 100 non-gun robberies. Cook (2018) observed that the 3:1 ratio was congruent with the difference in case-fatality rates for robbery and suggested a possible causal impact where robbery-murder was a by-product of robbery that occurred with a likelihood determined by the intrinsic lethality of the weapon deployed.

Using data from the National Incident-Based Reporting System (NIBRS), Libby & Corzine (2007) investigated the impact of weapon type on the lethality of violent interpersonal encounters. Controlling for incident circumstance, the relationship between the offender and victim, and their respective characteristics, firearms were found to have the strongest effect on the lethality of violent encounters, with handguns and shotguns representing the most lethal weapons overall (Libby & Corzine 2007). Similarly, Weaver et al. (2004) found that incidents involving firearms were 11 times more likely to result in victim homicide compared to unarmed assaults, whereas the use of knives was only approximately 2.5 times more likely to result in victim homicide. These findings support previous research in demonstrating independent weapon instrumentality effects, even when controlling for approximate measures of offender motive and intent (Wells & Horney 2002).

Weapon type has also been shown to influence victim mortality in family and intimate assaults. Research by Saltzman et al. (1992) showed that firearm assaults were three times as likely to result

in death as assaults involving knives or other cutting weapons, and approximately 23 times as likely to result in death as assaults involving other weapons or bodily force. Overall, family and intimate assaults with a firearm were 12 times more likely to result in death than non-firearm assaults. Additionally, approximately 50% of assaults with firearms resulted in a nonfatal injury, compared to 66% of assaults with knives, indicating that firearm attacks were less likely to result in nonfatal injuries than were knife attacks (Saltzman et al. 1992).

These findings reinforce other research in demonstrating that gun assaults are particularly lethal. For example, Felson & Messner (1996) found that offenders who used a gun were more than 40 times more likely to kill the victim than offenders who did not use a weapon; comparatively, offenders who used a knife were only 4.4 times more likely to kill the victim than offenders without weapons. Additionally, guns were more strongly associated with homicides when the initiating offense was an assault compared to a robbery, suggesting that guns facilitate homicide for offenders with a determination to kill, as offenders engaging in assault are more likely than offenders engaging in robbery to harbor lethal intent (Felson & Messner 1996).

This question of intent motivated some of the earliest studies related to firearm instrumentality. Wolfgang's (1958) seminal study of homicide in Philadelphia posited that few homicides would be prevented solely by eliminating the presence of firearms, as determined offenders would likely substitute other weapons to achieve the same result. Wright et al. (1983) concur with this observation and suggest that firearms simply make the act of killing easier. If no guns were available and the assailant was committed to completing the act, they would find another method of achieving it. But it was roughly 50 years ago that Zimring (1968, 1972) offered the first critical tests of the extent of overlap between fatal and nonfatal attacks in an effort to disentangle whether instrumentality or intentionality distinguished homicides from serious assaults (either with guns or with other weapons). Although he could not directly measure intentionality with existing official data, he suggested that it could be inferred if firearm homicides exhibit different features—such as victim–offender relationship, motive, location of wounds, number of wounds, etc.—from nonfatal attacks. Contrary to Wolfgang (1958), Zimring (1968, p. 722) believed that at least some homicides may be ambiguously motivated rather than "deliberate and determined," and "if the probable substitute for firearms in these situations is less likely to lead to death, then the elimination of guns would reduce the number of homicides." His research showed substantial similarities between the profiles of homicides and serious assaults, implying an ambiguity in intent to kill and leading him to conclude that what distinguishes a homicide from an assault is simply that the victim does not survive the attack.

As noted earlier, intentionality may be evaluated even more directly on the basis of the location of the wound (Braga & Cook 2018; Zimring 1968, 1972). Those determined to commit homicide should target vital organs or areas of the body, including the trunk of the body or the head, rather than extremities, like arms or legs. Yet Zimring (1968) found that nearly half of all gun attacks (44%) in Chicago resulted in wounds to nonvital parts of the victim's body, whereas a majority of knife attacks known to police resulted in wounds to the head, neck, chest, or back. This means that attackers with a gun appear to no more intend a fatal outcome than do attackers using other weapons, and because "the rate of knife deaths per 100 reported knife attacks was less than 1/5 the rate of gun deaths per 100 reported gun attacks" (Zimring 1968, p. 728), substituting knife attacks for gun attacks should drive the homicide rate down by a large margin. If intention is relatively even across attacks that end in fatalities and those that do not, then the major factor distinguishing homicides from assaults is the dangerousness of the weapon. This is particularly problematic, as guns can be fired from longer ranges, more easily, and with less skill than can other weapons of choice for assailants.

Even among only those attacks committed with a gun, if larger-caliber guns produce a greater proportion of homicides versus assaults under similar circumstances, then the dangerousness of the weapon can be said to independently contribute to fatalities. Excluding shotguns and large-caliber rifles, Zimring's (1972, p. 105) analyses showed that .38 caliber attacks to the head and chest, in particular, but also the abdomen, back, and neck were "more than twice as deadly as .22 caliber attacks" to the same areas, providing additional support for an instrumentality argument. Based on these two influential studies, Zimring (1972, p. 110) concluded that patterns in fatal and nonfatal gun attacks are highly similar in "structure, intention, and motivational background" and, furthermore, that intent to kill is largely ambiguous across gun homicides and serious but nonfatal gun assaults. The results of this early work and later replications (Sarvesvaran & Jayewardene 1985, Vinson 1974) provide direct support for the instrumentality effect, wherein guns influence the lethality of attacks primarily as a function of their dangerousness (see also Braga & Cook 2018, Cook 1991, Cook & Ludwig 2000, Cook et al. 2019, Zimring & Hawkins 1997).

In a more recent and comprehensive study on weapon instrumentality and intentionality, Braga & Cook (2018) demonstrated that, compared to smaller-caliber firearms, larger-caliber guns produce substantially more fatalities among shooting victims in Boston. Their research showed that the circumstances, neighborhood, prior criminal history, and demographic characteristics of fatal and nonfatal shootings are indistinguishable. Given the substantial overlap in the features of gun homicides and nonfatal shootings, and mirroring the findings in Zimring's 1970s Chicago studies, Braga & Cook (2018) argued that there was little evidence to support the contention that fatal and nonfatal shootings are qualitatively distinct. They then examined a subset of those cases in which the caliber of the weapon used in the shooting was known to police. Compared to nonfatal shootings, gun homicides were found to be significantly more likely to involve large-caliber handguns, to be characterized by a greater number of shots fired, to result in multiple gunshot wounds to victims, and to wound the victim in the head or neck relative to peripheral parts of the body (Braga & Cook 2018).

If the selection of a more powerful, larger-caliber handgun were dependent on the attacker's intention to kill, however, then the characteristics of shootings involving small-caliber handguns should differ from the features of shootings involving medium- and large-caliber handguns respectively. Yet Braga & Cook's (2018, p. 1) research illustrated that "caliber was not significantly correlated with other observable characteristics of the assault, including indicators of intent and determination to kill," such as the number of wounds, the location of wounds, and victim characteristics. In effect, there was no evidence that sex, race, age, criminal history, circumstances of the shooting, the skill and determination of the shooter, or other features of incidents were associated with the caliber of the handgun used in the attack. Consequently, shooters do not appear to be selecting a more powerful handgun according to their intent to kill. This "lack of systematic association is what would be expected if caliber were assigned at random, as in an experiment" (Braga & Cook 2018, p. 6).

The overlap in profiles of fatal and nonfatal shootings combined with the failure of incident-specific characteristics to distinguish shootings involving small- versus large-caliber guns enables a strict test of weapons instrumentality. That is, if the size and power of the handgun used in a shooting influence the likelihood of death independent of other features of the violence, and there is no direct effect of those features on the selection of the type of handgun, then the argument for instrumentality is considerably stronger. In a model predicting fatal versus nonfatal shootings, Braga & Cook (2018) found that victims of attackers who use a medium-caliber handgun are more than twice as likely to die as a consequence of the shooting as those who are shot with a small-caliber handgun, and those odds double for victims shot with large-caliber handguns. They conclude that "if the medium- and large-caliber guns had been replaced with small-caliber (assuming everything

else unchanged), the result would have been a 39.5% reduction in gun homicides" (Braga & Cook 2018, p. 7). Importantly, then, gun fatalities are substantially elevated in the context of attacks with more powerful firearms, holding other features of the shooting constant.

Collectively, the studies that most directly focus on intentionality and instrumentality in gun violence point to a relatively clear conclusion: the dangerousness of the instrument used in violent attacks plays a critical role in producing fatal outcomes. Attackers using larger-caliber guns conduct attacks that bear striking similarities to those who use smaller-caliber guns in circumstance, accuracy, number of shots fired, and the location of wounds to victims (Braga & Cook 2018; Zimring 1968, 1972). Yet the likelihood of death increases with the power of the firearm used in the attack; larger-caliber weapons are increasingly likely to produce lethal consequences. Ultimately, then, "whether the victim of a serious assault lives or dies is to a large extent a matter of chance, rather than a question of the assailant's intent. The probability of death is connected to the intrinsic power and lethality of the weapon" (Braga & Cook 2018, p. 8). From a public health perspective, reducing the objective dangerousness of gun violence could be accomplished more readily by controlling the size and power of firearms available to the public than by assuming intentionality on the part of the offender on the basis of what amount to chance outcomes in shooting incidents.

Offender Firearm Use, Victim Compliance, and Injury Incidence Rates

Weapon instrumentality effects also appear to influence the likelihood that violent incidents result in any injury to victims. Using data from the 1979–1985 NCVS and the FBI's 1982 Supplementary Homicide Report, Kleck & McElrath (1991) assessed the impact of various weapon types on the likelihood that a threatening situation escalated into a physical attack, whether the attack resulted in an injury, and whether the injury resulted in the death of the victim. Regarding the likelihood of injurious attacks on victims, the study suggested that the net effect of the presence of deadly weapons—firearms and, to a lesser extent, knives—in threatening situations is to reduce the probability that the possessors of the weapons attack. As the lethality of the weapon present increases, the probability of a physical and injurious attack decreases (Kleck & McElrath 1991). In effect, the threat alone is sufficient to subdue the victim. Libby (2009) attempted to replicate these findings using National Incident-Based Reporting System (NIBRS) data for 2003–2005 and generally confirmed the results of Kleck & McElrath (1991). His analysis indicated that the chances of nonlethal victim injury decreased by approximately 80% in incidents featuring a firearm. However, when firearms were used in the commission of a crime, the likelihood of death was substantially greater (Libby 2009).

Research suggests the source of these more nuanced instrumentality effects of guns on injury incidence may be rooted in offender decision-making processes and victim resistance in violent attacks. Criminal offenders may use firearms to facilitate the successful commission of their intended crimes (Jacobs 2000, Kleck & McElrath 1991, Wright & Decker 1997, Wright & Rossi 1994). Guns also tend to be used when offenders are planning robberies that involve larger amounts of cash and/or more expensive items (Cook 2009). Robbers report their desire to use the overwhelming force made possible through firearms to secure victim compliance via the threat of serious injury and death (Feeney 1986, Jacobs 2000, Wright & Decker 1997). In noncommercial robbery cases, the standard technique is to threaten victims and take their valuables without actually attacking them [78% of gun robberies and 64% of knife robberies (Cook 1980)]. In contrast, 74% of unarmed noncommercial robberies and 60% of blunt instrument noncommercial robberies involved physical attacks on victims followed by attempts to take their valuables by force (Cook 1980). The likelihood of injury followed the same pattern, ranging from only 11% of gun

robberies to 36% of robberies with blunt instruments (Cook 1980). As described earlier, when guns are present and fired, victim injuries are far more likely to be lethal.

Although less developed than the empirical evidence on weapon use in robbery, qualitative interviews with sexual assault offenders similarly show that they use weapons like guns to control their victims, discourage resistance, and secure compliance (Beauregard & Leclerc 2007, Reid & Beauregard 2017). As one serial sex offender noted, "It was better to threaten a victim with a gun when she was further away; she knew I could shoot her from that distance, which isn't the case with a knife" (Beauregard & Leclerc 2007, p. 123). Offender views on the subduing power of guns seem to be well supported, as victims were less likely to resist and offenders were more likely to complete the robbery or sexual assault successfully when a firearm was present (Cook 1980, 2009; Kleck & DeLone 1993; Libby 2009; Tillyer & Tillyer 2014).

Physical assaults sometimes serve as an inappropriate outlet for negative emotions or deep frustrations held by violent offenders (Langhinrichsen-Rohling et al. 2012). Kleck & McElrath (1991) considered a broad spectrum of assaults ranging from mere threats to homicides at multiple stages of the incident to explore this hypothesis. They suggest that offenders can successfully threaten or intimidate their intended target with the mere presence of a firearm, whereas they may need to objectively demonstrate their power through actual physical harm if in possession of another weapon type. Using event history analysis, Wells & Horney (2002) extended this line of inquiry by assessing how possession of a weapon influenced the likelihood of an attack and subsequent injury while controlling for offender intent. Their results indicated that persons armed with a firearm were more likely to confront a victim than those armed with another type of weapon; however, incidents featuring firearms were substantially less likely to result in any injury to victims.

Despite some contradictory evidence (Tark & Kleck 2004), the available research generally suggests that the mere threat of gun injury assists offenders in achieving their aims and often nullifies the need to use deadly force. As such, offenders do not typically employ firearms in an effort to inflict maximum harm against their victims (Zimring 1968) but rather to avoid potential confrontation and injury through implicit assertions of dominance. However, in cases in which the victim is attacked and injured, the likelihood of death in violent gun crimes is far higher than with knives or blunt objects, which accounts for the relatively high case-fatality rate for incidents featuring guns.

POLICY IMPLICATIONS

The most important implication of instrumentality effects is that policies that decrease gun use in violent crime should reduce the homicide rate even if the overall volume of violent crime was unchanged (Cook et al. 2011). A variety of law enforcement approaches attempt to reduce gun violence by incapacitating those who have been convicted of gun crimes and deterring future gun crimes. Others suggest that policies designed to deprive potentially violent people of guns could save lives (Cook et al. 2011). This is a central element of the argument to restrict gun availability. In this section, we first discuss criminal justice approaches to reduce gun use by violent criminals, briefly review the existing evidence on the relationship between gun availability and violent crime, and summarize the impacts of gun control legislation designed to reduce gun availability on violence.

Firearm sentence-enhancement laws require minimum mandatory sentences or additional time in prison for gun felonies. To many observers, gun use in robberies and assaults deserves harsher punishments because of the increased chance that victims are killed (Cook & Nagin 1979). Sentencing enhancements are intended to reduce gun use in violence, encourage desistance from violent gun crimes, and induce prospective gun offenders to substitute less-lethal weapons. What

is more, stiffer prison penalties for gun crimes do not impact the ability of law-abiding citizens to own guns for recreational and self-defense purposes. As such, this approach is supported by gun control and gun rights advocates alike. Although there is some evidence to the contrary (e.g., Marvell & Moody 1995), the available research evidence suggests firearm sentence-enhancement laws generally seem to work in reducing gun violence (see, e.g., McDowall et al. 1992, Pierce & Bowers 1981). In a careful analysis of state-level firearms sentence enhancements, Abrams (2012) found that the introduction of these laws in several states reduced gun robberies by 5% without any discernible impact on non-gun robberies.

A more controversial approach to reducing gun violence involves focusing local law enforcement agencies on deterring illegal gun possession and carrying in public spaces. Police departments need to ensure that such approaches safeguard against illegal searches and seizures and do not devolve into harassment of citizens, especially young minority men, lawfully present in public places (Moore 1980). However, the available empirical evidence suggests gun-oriented patrols can reduce gun violence (Cohen & Ludwig 2002, McGarrell et al. 2001, Sherman 2000). Gun violence tends to concentrate in very small hot-spot locations in urban environments (Braga et al. 2010). Hot-spots policing programs designed to increase gun seizures have been shown to generate significant reductions in gun violence without causing negative externalities such as crime displacement or police-community relations problems (Braga et al. 2019, Sherman & Rogan 1995).

Another criminal justice–led intervention attempts to deter groups of high-rate offenders from using guns to settle ongoing disputes with other criminally active groups. Focused deterrence, sometimes called pulling-levers policing, follows an action research model that tailors the strategy to specific gun violence problems and builds upon local operational capacities to deliver sanctions and mobilize support to control those high-rate offenders who drive persistent gun violence (Braga et al. 2001, Kennedy 2011). Focused deterrence attempts to prevent gang and group-involved violence by making group members believe that gun use by any one member of the group would result in legal problems for all members. The intent is to create an incentive for group members to discourage each other from gunplay, thus reversing the usual group norm in support of violence. A key element of the strategy involves the delivery of a direct and explicit "retail deterrence" message to a relatively small target audience regarding what kind of behavior would provoke a special law enforcement response and detailing what that response would be. Social services are provided to gang and criminally active group members who want to change their life trajectories. The deterrence message is delivered by talking to gang members on the street, handing out fliers in the hot-spot areas explaining the enforcement actions, and organizing forums between violent group members and representatives (Kennedy 2011). A growing body of rigorous program evaluation evidence suggests focused deterrence programs are effective in reducing gang and group-involved gun violence problems (Braga et al. 2018).

Reducing firearm availability can make violent events less lethal. The difficulty and legal risks associated with obtaining and using guns influence offender decisions on what weapon to use when committing a crime (Wright & Rossi 1994). Reducing firearm availability should, in turn, reduce the prevalence of guns used in violent crimes. However, to some observers, widespread access to guns induces a deterrent effect on criminal behavior as offenders' fear of confronting potentially armed victims should dissuade them from crime (Kates & Mauser 2006, Lott 2010). The proposed negative relationship between firearm availability and crime reduction (or "more guns, less crime") has been generally unsubstantiated when sound measurement and methodological strategies are utilized (Cook & Ludwig 2006a, Kleck 2015). And although guns certainly give some law-abiding citizens the opportunity to escape injury at the hands of violent criminals, it remains unclear how often guns are actually used in self-protection. Definitional issues about what constitutes defensive

gun use make it difficult to develop reliable and valid estimates of the annual frequency of such events (Cook et al. 2011, Natl. Res. Counc. 2005).

Attempts to analyze the relationship between firearm availability and violent crime are characterized by substantial variation in the methodological approaches used by analysts. The current state-of-the-art considers how temporal and spatial differences in community gun ownership affect the extent and nature of violent crime. The United States exhibits the highest rate of civilian gun ownership in the world with more than 350 million guns in private hands (Inst. Med. & Natl. Res. Counc. 2013). However, gun prevalence varies markedly across communities—e.g., states, counties, and cities—and over time (Cook et al. 2011). Comparisons across place, time, or both afford researchers insight into the relationship between community gun availability and violent crime. However, such analyses are often complicated by unreliable measures of community firearm prevalence. Although a precise measure of gun prevalence proves elusive due to the lack of centralized administrative data on gun ownership, the proportion of suicides that involve a firearm [firearm suicides/total suicides (FS/S)] is generally regarded as a well-validated proxy measure (for a discussion, see Natl. Res. Counc. 2005). Analyses of survey data generally find that FS/S is highly correlated with gun ownership rates and, furthermore, these data can be used to reliably track trends in gun prevalence over both space and time (Azrael et al. 2004, Cook et al. 2011, Kleck 2004).

The preponderance of empirical evidence indicates that higher levels of firearm ownership do not have any effect or, at best, only modest effects on overall violent crime rates (Cook & Ludwig 2006b, Cook & Pollack 2017, Duggan 2001). Firearms do not necessarily intensify the prevalence of violent crime, as rates of assaults and robberies appear largely unaffected by the availability of guns. However, examining the effects of gun availability on homicides demonstrates their critical role in shaping the outcomes of violent encounters. Whereas the connection between firearms and the general incidence of violence appears weak, strong and positive associations between community gun ownership rates and homicide rates indicate that guns do increase the intensity and lethality of violence. These positive associations are observable across regions (Miller et al. 2002), states (Siegel et al. 2013), counties (Duggan 2001), and cities (Cook 1979). Furthermore, studies using longitudinal methods and appropriate measures of gun prevalence suggest that this increase in lethality is restricted to just the firearm homicide rate, as non-firearm homicides, like general levels of nonlethal crime, appear unrelated (Cook & Ludwig 2006b, Miller et al. 2002, Siegel et al. 2013). Consistent with the instrumentality hypothesis, firearms alter the quality and lethality of violence but not its quantity.

Recent studies indicate that high levels of community gun ownership may extend to other forms of lethal violence such as police use of deadly force and the homicide of on-duty police officers. The majority of persons shot at and/or killed by the police were in possession of a firearm at the time of the incident and the majority of felonious killings of police officers are committed with a firearm (Klinger et al. 2016, Zimring 2017). State-level analyses document significant and positive associations between state gun ownership rates and both rates of fatal police-involved shootings and homicides of law enforcement officers, independent of other contextual factors (Hemenway et al. 2019, Swedler et al. 2015). In the case of police use of deadly force, gun prevalence was positively associated with the shooting rate of citizens armed with guns and, to a lesser degree, citizens armed with other types of weapons. Nagin (2020) similarly found positive associations between firearm ownership and the prevalence of fatal police shootings, demonstrating that this relationship was observed across race.

Finally, some studies have also examined this issue by evaluating the impacts of gun control legislation and gun ownership levels on violent crime rates. For instance, a cross-sectional analysis of 170 cities with a 1980 population of 100,000 residents or greater found that gun prevalence

levels generally had no net positive effect on total violence rates; homicide, gun-assault, and rape rates increased gun prevalence; gun control restrictions had no net effect on gun prevalence levels; and most gun control restrictions generally had no net effect on violence rates (Kleck & Patterson 1993). These findings provide some support to the notion that more-restrictive gun laws merely force offenders to shift from guns to other weapons in their criminal pursuits while failing to reduce overall homicide or crime rates (Kleck & Patterson 1993). Relatedly, Kleck (1984) suggests that criminals might substitute rifles and shotguns in response to handgun control policies, and the use of more powerful firearms could ultimately serve to increase the death rate.

Other research, however, supports the use of policies that are aimed at restricting the accessibility of handguns to high-risk individuals (Cook et al. 2011). For instance, Wright et al. (1999) assessed whether denial of handgun purchase can influence an individual's subsequent risk for crimes involving guns or violence. Specifically, individuals with a prior felony conviction who were denied the purchase of a handgun were compared over a 3-year period to individuals with prior felony arrests who purchased handguns. The results indicate that the denial of handgun purchase was associated with a 20% to 30% reduction of risk for new crimes involving guns or violence (Wright et al. 1999), supporting the findings of other research (Wintemute et al. 1999). Indeed, much of the gun violence problem is concentrated among prohibited possessors and other high-risk individuals and gun control policies designed to keep firearms out of the wrong hands could be used to good effect in reducing serious violence (Braga & Cook 2018, Cook et al. 2005).

CONCLUSION

The potential lethality of gun violence has motivated vigorous debate about the utility of gun control for reducing fatalities. From a dangerousness perspective, if the weapons used in assaults were less deadly (hands, knives, etc.), fewer people would die. But this premise rests on the assumption that there is nothing distinctive about gun violence vis-à-vis non-gun violence, save for the weapon of choice. That is, those intent on committing assault may be more likely to cause fatal injuries to the victim if they attack with a gun; however, their intent to injure is no different than had they opted for a knife or stick or any other available weapon. The outcome may vary, but the goal does not. Consequently, the instrumentality of firearms, or their heightened potential for causing fatal injury relative to other kinds of weapons, elevates the chances of death (Braga & Cook 2018; Cook et al. 2019; Zimring 1968, 1972). Alternatively, if gun violence represents a clear intent to kill that is absent in other types of assault or attack, the features of assaults with guns versus assaults with other weapons should be distinctive. In this latter scenario, intentionality drives the attack; fatal outcomes are more likely not because guns are more dangerous but rather because the attacker chooses a more dangerous weapon to achieve the result they intend.

Our review of the available scientific evidence suggests that guns do indeed make violent situations more lethal. It is important to note that the type of weapon used in violent situations matters in several ways. Guns are usually not fired and the victims of most gun assaults and gun robberies are not injured. Criminals deploy guns to control violent encounters and intimidate their victims without actually firing bullets and generating gunshot wounds. Victims are much more likely to resist attackers who use knives, blunt instruments, and other means. As such, victims in non-gun assaults are more likely to suffer injuries. However, when gun assaults and gun robberies result in injuries, victims are much more likely to die. Many factors influence mortality in injurious gun assaults; the number and placement of gunshot wounds on victims significantly influence the lethality of gun attacks, as do factors such as how quickly first responders provide initial aid and the proximity of high-quality trauma care centers. Finally, the technology of the guns deployed

in injurious assaults influences mortality, wherein firearms with higher-capacity magazines and larger-caliber bullets are more deadly than guns without these features.

The guns used in violent crime are becoming more deadly over time, with the police recovering increasing shares of higher-capacity, large-caliber semiautomatic pistols. Yet case-fatality rates have stabilized, despite the more lethal technology of contemporary firearms, at roughly one gun homicide for every six victims with nonfatal gunshot injuries. Some evidence suggests that improved trauma care may be offsetting the increased lethality of handguns available to violence-prone individuals. Unfortunately, one-third of roughly 74,000 annual emergency department admissions for gunshot injuries are treated in community hospitals that do not have high-quality trauma centers (Coupet et al. 2019). Increasing the number of hospitals that can provide life-saving care for traumatic gunshot injuries may save lives and decrease case-fatality rates in underserved areas. It is also tempting to consider increasing the use of new technologies, such as Shotspotter acoustic gunshot detection systems, that get first responders to life-threatening gun assault scenes quickly so short-term care can be administered immediately and patients can be transported to trauma centers more rapidly.

The available program evaluation evidence suggests that criminal justice interventions designed to change offender decisions to use guns in violent crimes, such as firearm sentencing enhancements and proactive policing efforts, are effective in reducing gun violence. Another policy issue that undergirds consideration of firearm instrumentality effects, however, is whether interventions that reduce the availability of guns to potentially violent people reduce the homicide rate. To gun rights advocates, gun controls are futile, as determined killers will simply complete their acts via the substitution of other means. Research highlighted here appears to provide a strong counter to this enduring argument made by gun rights activists by challenging the notion that gun-assault outcomes are determined by the intent of the shooter. Zimring's (1968, 1972) seminal studies and the Braga & Cook (2018) update indicate enhanced gun controls could indeed reduce homicide. These studies suggest that gun homicides and nonfatal gun assaults with injury are very similar in terms of incident circumstances and the characteristics of offenders and victims. Furthermore, mortality in gun assaults seems to be strongly influenced by chance events rather than indicators of assailant intent to kill. Importantly, the research finds that the likelihood of death was systematically associated with the caliber of the gun deployed in the attack: More powerful handguns were more likely to result in the death of the gunshot victim. The selection of gun caliber in these violent events was not correlated with available indicators of shooter determination to kill, such as the location and number of wounds. In sum, reducing the lethality of the weapons available to would-be killers may result in fewer fatalities in gun-assault events.

The existence of firearm instrumentality effects supports a wide range of gun control efforts to reduce the availability of firearms to high-risk people (Cook et al. 2011). These policy interventions include tax initiatives to raise the price of guns and ammunition to dissuade violence-prone individuals from making purchases (Cook & Leitzel 1996), screening out high-risk purchasers via background checks (Ludwig & Cook 2000, Wintemute et al. 1999), regulating secondary firearms markets (Cook et al. 1995), and reducing illegal gun trafficking (Braga et al. 2012). Unfortunately, we do not currently have much guidance on what works in reducing the availability of guns to high-risk individuals (Inst. Med. & Natl. Res. Counc. 2013, Natl. Res. Counc. 2005). Like others, we think that it is time to experiment with alternative gun control measures in an effort to develop more effective interventions than the current array of policies and programs. And, in doing so, we should be mindful of potential substitution effects in which prohibited persons acquire guns through other mechanisms. For instance, a longitudinal study found that the passage of the Brady Handgun Violence Prevention Act of 1994, intended to screen out prohibited handgun purchasers through mandatory criminal history background checks at licensed gun dealers, had a negligible

effect on homicide rates (Ludwig & Cook 2000). However, the study authors suggested the homicide reduction impact of the Brady Act may have been undermined by continued criminal access to firearms through unregulated transactions made by unlicensed private sellers.

The potential impacts of developing such a portfolio of evidence-based gun control interventions could be quite large. One estimate suggests gun violence in the United States costs roughly US$100 billion per year (Cook & Ludwig 2006b). In their simulation of the impacts of the effects of replacing medium- and large-caliber handguns with small-caliber handguns on gun-assault outcomes, Braga & Cook (2018) estimate a near 40% homicide reduction if all shootings were committed with small-caliber handguns rather than the existing mix of large-, medium-, and small-caliber handguns. The RAND Corporation estimates that each murder costs some US$8.6 million and each aggravated assault costs roughly US$87,000 (RAND 2010). In 2018, there were approximately 10,265 gun murders in the United States (FBI 2018). If we were able to achieve a 40% reduction in gun deaths, the monetary savings would be in the range of US$35 billion. And, more importantly, such an intervention would spare families and friends the devastation of losing loved ones to senseless gun violence. As such, expenditures to test new interventions could ultimately prove to be highly cost-effective and reduce the tragic human costs perpetuated by ongoing gun violence in the United States.

DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

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Errata

An online log of corrections to *Annual Review of Criminology* articles may be found at http://www.annualreviews.org/errata/criminol

Exhibit S

Epidemiologic Changes in Gunshot Wounds in Washington, DC, 1983-1990

Daniel W. Webster, ScD, MPH; Howard R. Champion, FRCS(Edin); Patricia S. Gainer, JD, MPA; Leon Sykes, MD

• The purpose of this study was to examine temporal patterns in gunshot wound admission rates and wound profiles from 1983 through 1990 at a level I trauma center in Washington, DC. Data on trauma admissions were collected at the time of admission. Records were reviewed to identify patients admitted for gunshot wounds from assaults. Data on the number and location of entrance gunshot wounds, survival, complications, length of stay in the intensive care unit, and total inpatient days were recorded. Admissions due to gunshot wounds grew at an exponential rate beginning in 1987 and reached a level from 1989 through 1990 three times higher than the preepidemic rate. The mean number of entrance gunshot wounds per patient grew from 1.44 before the epidemic to 2.04 from 1988 through 1990. Multiple thoracic wounds became relatively more common from 1988 through 1990. This increase was partially responsible for reversing a downward trend in patient mortality. Temporal changes in admission rates and wound profiles were consistent with the city's epidemic of drug-related violence and with a shift in weaponry toward high-capacity, semiautomatic handguns.

(*Arch Surg.* 1992;127:694-698)

Interpersonal violence has grown to epidemic proportions in many US cities. Homicide is the 12th leading cause of death in the United States overall, and is the leading cause of death among black males aged 15 to 34 years.[1] Homicide rates for black males aged 15 to 24 years have nearly doubled between 1984 and 1988, and virtually all of the increase was attributable to gun-related homicides.[2] In 1985, even before the incidence of gun-related violence began to soar, direct medical care costs for treating patients with firearm injuries were estimated to be $863 million nationally.[3] Recent escalations in violence have placed considerable financial strain on urban trauma centers and have forced some to close.[4]

The increase in violence during the late 1980s in many US cities has been perhaps most dramatic in the nation's capital. The homicide rate in Washington, DC, per 100 000 population increased threefold, from 24 in 1985 to 78 in 1990,[5] during which time the city earned the appellation "murder capital of the nation" for having the highest rate of homicide of any US city. This dramatic increase has been largely attributed to violence surrounding the trade of crack-cocaine and has been most pronounced for gun homicides of young black males.[5]

Data collected by hospitals on fatal and nonfatal gunshot wounds (GSWs) can provide a more complete picture of gun violence than homicide statistics alone. Every firearm death represents an estimated 7.5 nonfatal shootings, 28% of which require hospitalization.[3] Hospital surveillance of injuries owing to firearm assaults indicate that many of these injuries do not show up in police statistics.[6]

Using medical records data, it is possible to study temporal changes in GSW profiles (ie, the number and location of entrance GSWs), which may be indicative of shifts in the prominence of particular types of gun attacks, the type of guns used, and the lethality of these attacks. For example, a study of violent crime in New York City revealed that homicide rates changed over time due to changes in the lethality of gun attacks, the lethality of attacks being largely determined by an assailant's intent to kill during assaults.[7] Drug-related assaults characteristically had a higher degree of intent to kill than assaults resulting from spontaneous arguments. Execution-style GSWs to the head or high numbers of GSWs to the chest are wound profiles indicative of a clear intent to kill.

MATERIALS AND METHODS

Data Collection

We used data collected at the Washington (DC) Hospital Center, a level I trauma center located in the north central part of Washington. The hospital treats 30% to 40% of all adult patients with GSWs who are treated at trauma centers in the city. Most of these patients are transported from high-crime sections of Washington.

Data collected for each GSW victim admitted included external cause of injuries, nature and severity of injuries, treatments and procedures, length of stay, complications, and patient discharge status. These data are reviewed and edited monthly for every trauma inpatient.

Patients admitted for GSWs were identified through a retrospective review of trauma admission records from January 1983 through December 1990. Cases were excluded if the GSWs were noted to be self-inflicted or unintentional. These exclusions left 1781 patients eligible for the study. For analyses of length of in-

Accepted for publication March 24, 1992.

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Description of Population of Patients Admitted for Gunshot Wounds From January 1983 Through December 1990

	Total	Age, y						
		<20	20-24	25-29	30-34	35-39	40	Unknown
Admissions, No.	1781	273	492	401	253	141	166	55
Deaths in hospital, No. (%)	379 (21)	58 (21)	87 (18)	77 (19)	55 (22)	25 (18)	37 (22)	40 (73)
Treated in intensive care unit, No. (%)	504 (28)	72 (26)	138 (28)	137 (34)	89 (35)	51 (36)	59 (36)	8 (15)

patient stay and number of days in the intensive care unit (ICU), the following categories of patients were excluded: patients who died in the hospital, patients who were discharged to another acute care facility, and patients who had significant injuries other than GSWs (eg, injuries associated with a motor vehicle crash that occurred after the shooting).

Data Analysis

Based on published homicide statistics, news reports of increased drug-related violence, and data from the firearms identification unit of the DC Metropolitan Police Department, we anticipated that there would be differences in GSW patterns between 1983 and 1986 and 1988 and 1990, with 1987 being the year of transition. Trends in GSW patterns were described using plots of monthly, quarterly, and annual time-series data. Five-month moving averages were calculated and plotted to smooth monthly plots. When appropriate, patients admitted for stab wounds due to assaults were used as a comparison group. For mortality and morbidity analyses, patients were assigned to one of four categories based on the location of wounds: (1) any head wound, (2) thoracic wound with no head wound, (3) wound to the face, neck, abdomen, or pelvic region and no head or thoracic wound, or (4) wounds confined to extremities.

Most of the analyses were descriptive in nature, and in some instances, statistical tests were unnecessary to determine that a temporal shift had occurred. The statistical significance of differences in proportions was assessed using Pearson's χ^2 analysis with Yates' correction. Annual medians were calculated to examine changes in length of inpatient stays since means are highly affected by extreme values.

Annual population estimates for the hospital's catchment area for trauma admissions were not available. Therefore, trends in the number of GSW admissions were analyzed without the benefit of data on the population located in the catchment area. It is unlikely that shifts in the population would have a substantial effect on GSW admission during the 8-year observation period. Neither the estimated 3.3% decline in the city's population from 1983 to 1990 nor the District of Columbia's emergency medical services system procedures for transporting patients to trauma centers are believed to have had a substantial effect on the volume of patients transported to any specific trauma center.

RESULTS

Description of Study Population

From January 1983 through December 1990, 1781 patients were admitted to Washington Hospital Center's level I trauma center for GSWs that were not believed to be self-inflicted or unintentional (Table). Overall, 21.3% (379 of 1781) died in the hospital and 28.3% (n = 504) were admitted to the ICU. Patients aged 20 to 24 years had the highest number of admissions (27.6%), and patients older than age 40 years had the highest risk of in-hospital mortality (22.3%). Only 8.5% (150 of 1755) of the patients were female (data not shown).

Gunshot Wound Admission Trends

Figure 1 shows a sharp increase in the number of GSW assault admissions that began during the last half of 1987.

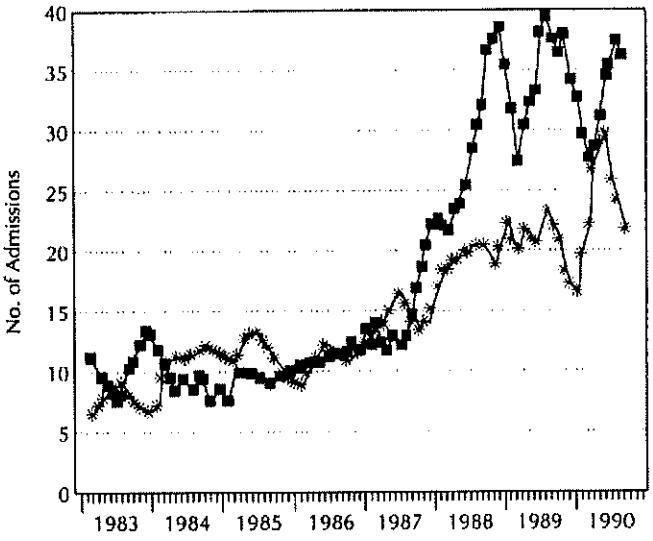

Fig 1.—*Five-month moving average of monthly admissions for gunshot wounds (squares) and stab wounds (asterisks) from 1983 through 1990 (calculated using monthly, quarterly, and annual time-series data).*

From January 1983 through June 1987, the mean±SD number of GSW assault admissions was 10.2±3.4 per month, with no apparent trend. Despite some normal monthly fluctuations, GSW admissions rose steadily from the last half of 1987 through January 1989. After having 46 admissions in January 1989, monthly GSW admission dropped off to 33.2±8.2 for the remainder of the study period, with considerable month-to-month variation.

Monthly admissions for stab wounds also began to increase in 1987, and from 1988 through 1990 (20.6±4.8) levels were double those from 1983 through 1986 (9.9±3.0). The less dramatic increase in admissions for stab wounds compared with GSWs altered the ratio of GSW to stab wound admissions from 1:1 from 1983 through 1986 to 1.5:1 from 1988 through 1990.

Consistent with the pattern of homicide increases in Washington, DC,[5] increases in GSW admissions were most pronounced among males younger than age 20 years. Admissions of teenagers for GSW assaults increased from an annual average of 7.5 admissions (6.4%) in 1983 and 1984 beginning in 1985 before leveling out to 76 admissions (19.3%) per year in 1989 and 1990. (Most serious injuries to children and adolescents younger than 18 years are treated at nearby Children's Hospital National Medical Center.) With the exception of those younger than 20 years, the general temporal pattern in GSW admissions did not vary substantially among age groups. The proportion of patients with GSWs who were female ranged from 5.0% in 1988 to 11.8% in 1990; however, no clear temporal pattern in the gender of patients with GSWs was evident.

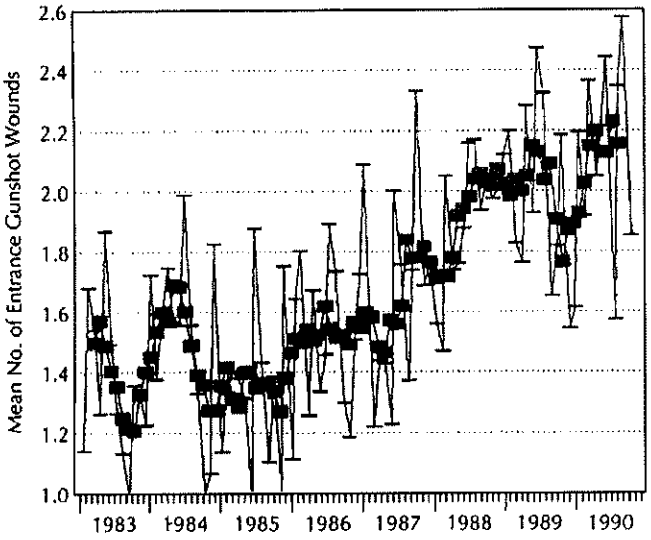

Fig 2.—*Mean number of entrance gunshot wounds per patient by month from 1983 through 1990. Squares indicate moving average; bars, observed value.*

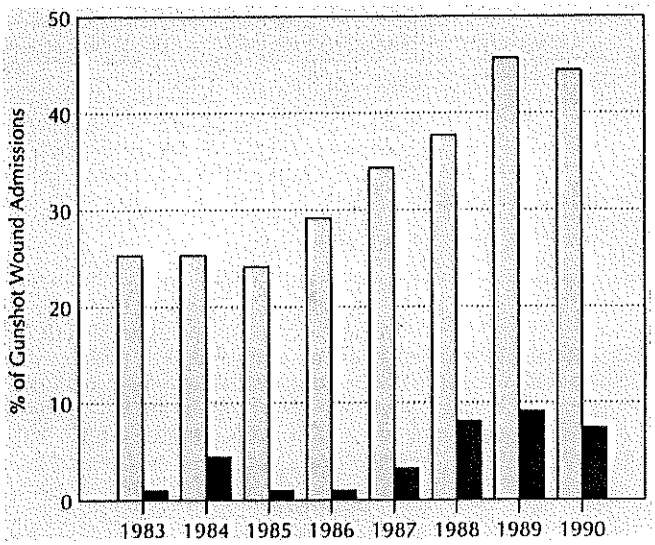

Fig 3.—*Percentage of all admissions for patients with two or more entrance gunshot wounds (shaded bars) and percentage of those with five or more entrance wounds (solid bars) from 1983 through 1990.*

Number of Wounds per Patient

The mean number of entrance GSWs per patient is displayed by month in Fig 2. From January 1983 through June 1987, the mean number of entrance GSWs per patient fluctuated around 1.44±0.28. After a 13-month ascent that leveled off in August 1988, the mean number of GSWs per patient fell off somewhat to 2.04±0.28 for the remaining study period.

Figure 3 depicts the temporal change in the percentage of patients with multiple entrance wounds. The proportion of patients with two or more entrance wounds grew from 25.9% (123 of 475) before 1987 to 43.0% (487 of 1132) from 1988 through 1990 (χ^2, 40.95; *df*, 1; $P<.001$). After 1987, the large number of entrance wounds also became more common. The proportion of patients with five or more entrance GSWs nearly quadrupled from 1.7% (eight of 475) from 1983 through 1986 to 7.9% (89 of 1132) from 1988 through 1990 (χ^2, 21.44; *df*, 1; $P<.001$).

Body Region and Patient Mortality

Patients with GSWs to the head and/or thorax made up 85.2% (323 of 379) of in-hospital deaths. As expected, patient mortality trends from 1983 through 1986 mirrored changes in the percentage of patients with head or thoracic wounds (Fig 4). The 1984 peak in mortality rate coincided with proportionate annual highs in patients with head wounds and/or thoracic wounds (58.3%, 67 of 115). The mortality rate declined from 1984 to 1986 as fewer patients presented with head or thoracic wounds. Patient mortality continued to decrease from 1986 to 13.6% (23 of 169) in 1987, even though the percentage of patients with head or chest wounds increased slightly between the two years.

Patient mortality increased from 1987 through 1990, even though the percentage of patients with head or chest wounds remained relatively constant until the percentage of admissions due to head wounds fell to 10.8% (42 of 390) in 1990. The increase in patient mortality during the last 3 years of the study was partially attributable to increases in the proportion of patients with multiple thoracic wounds, from 3.0% in 1987 to 7.6% in 1990. In-hospital mortality was 49.0% (48 of 98) among patients with multiple thoracic wounds

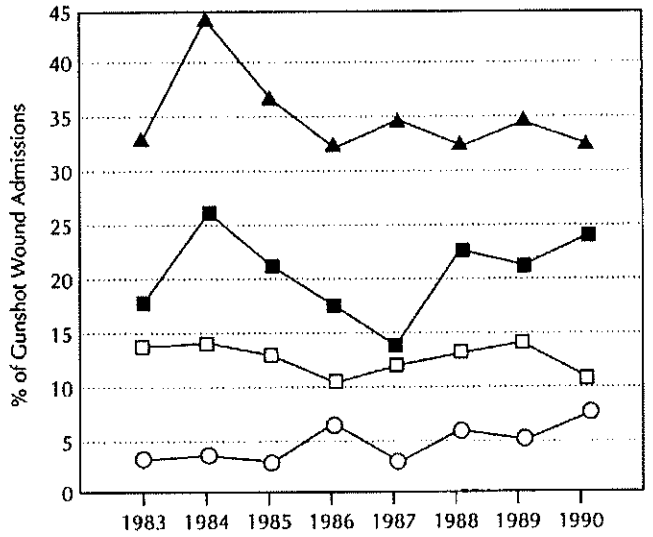

Fig 4.—*Patient mortality and the percentage of patients with gunshot wounds who have the most lethal wound profiles from 1983 through 1990. Triangles indicate one or more thoracic wound(s); solid squares, mortality; open squares, head wound(s); and open circles, multiple thoracic wound(s).*

compared with 30.5% (164 of 538) among patients with a single thoracic wound (χ^2, 11.94; *df*, 1; $P=.0005$).

The temporal pattern for GSW patient mortality was also a function of shifts in mortality from wounds to body regions with vital organs (Fig 5). For example, the rise in overall mortality from 1987 to 1988 and 1990 was driven by increases in mortality among patients with head wounds, from 45.0% (nine of 20) in 1987 to 62.0% (88 of 142) from 1988 through 1990 (χ^2, 1.45; *df*, 1; $P=.23$). Mortality among patients with thoracic wounds and no head wounds also grew from 15.3% (nine of 59) in 1987 to 35.1% (133 of 379) from 1988 through 1990 (χ^2, 8.29; *df*, 1; $P=.004$).

Morbidity

Annual median length of inpatient stay for patients with GSWs dropped from 5.5 days in 1985 to 3 days in 1987, then increased to 6 days in 1989 and 1990 (Fig 6).

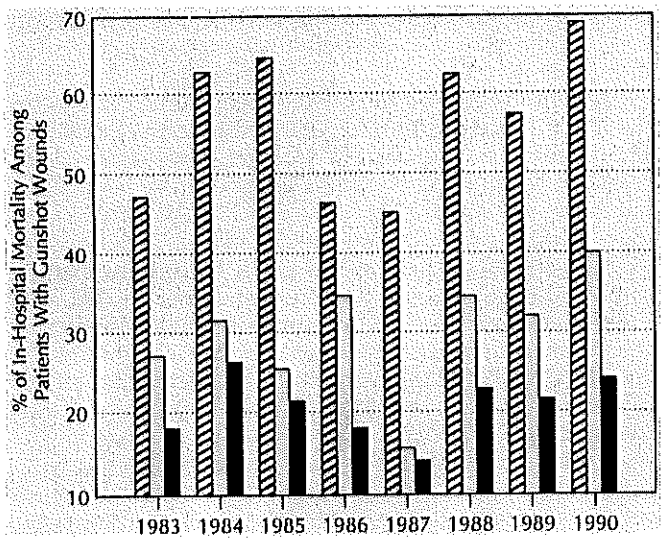

Fig 5.—*Percentage of patients with gunshot wounds who died in the hospital by body region of entrance wound(s) from 1983 through 1990. Hatched bars indicate head wound(s); shaded bars, thoracic wound(s); and solid bars, total of all gunshot wounds.*

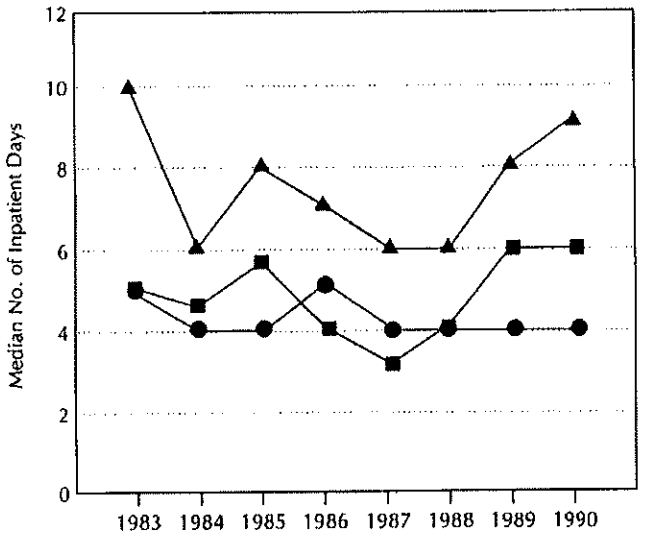

Fig 6.—*Median number of inpatient days for all patients with GSWs (squares), patients with GSWs to the thorax (triangles), and patients with stab wounds (circles) from 1983 through 1990.*

Although the temporal pattern of inpatient stay was partly attributable to proportional changes in the body regions wounded, the V-shaped pattern for median length of stay for all patients with GSWs from 1985 to 1990 follows the same pattern as trends for patients with thoracic wounds. Temporal patterns in median length of inpatient stay were similar for patients with wounds to the abdomen, face, or neck (data not shown). Trends in length of stay were not studied for patients with GSWs to the head who survived because such cases were relatively rare in the early and mid-1980s. Length of stay for patients with stab wounds varied little during the study period, suggesting that discharge practices for patients with penetrating trauma were unlikely to have affected the observed changes for patients with GSWs.

Temporal changes in average ICU stays for patients with GSWs followed virtually the same pattern as that of total inpatient stays (data not shown). Aggregate ICU stay averages were also propelled by dramatic increases for patients with thoracic wounds, as the mean number of ICU days went from 0.44 in 1987 to 2.22 in 1990.

COMMENT

The threefold increase in GSW admissions to Washington Hospital Center beginning with the last quarter of 1987 was consistent with the rate at which homicides increased in the District of Columbia.[5] Gunshot wounds also became more severe, which may have been partially responsible for the city's increase in homicides. The in-hospital mortality rate had declined steadily from 1984 to 1987, before shifting markedly upward from 1988 through 1990. This reversal in mortality trend was a function of higher mortality within body regions and an increase in the proportion of patients with multiple thoracic wounds. Trends in inpatient length of stay also suggest that GSWs became more severe.

Assessments of temporal changes in the lethality of gunshot injuries may be biased when relying solely on hospital data if the proportion of homicides in which the victim dies at the scene changes over time. Unfortunately, data on the site of death for homicides were not available from the city medical examiner. Police data indicating a 51% increase in the ratio of gun-related homicides to assaults between 1983 through 1987 and 1988 through 1990 support the hypothesis that gun attacks in Washington, DC, have become more lethal.[5]

The epidemic of gun violence in our nation's capital has led to substantial increases in medical care costs that have been borne primarily by taxpayers and trauma centers. Hospital costs associated with treating victims of criminal violence in the District of Columbia were estimated to be $20.4 million in 1989.[8] Washington Hospital Center's costs of treating patients with GSWs were not available throughout the study period; however, increases in patient volume alone resulted in a dramatic rise in costs. Using financial data from patients with GSWs in fiscal 1990 (July 1, 1989 through June 30, 1990), the mean cost for hospital care per patient with GSWs was estimated to be $14757, excluding physician fees. (This estimate is based on an estimated Medicare cost-to-charge ratio of 0.57.) During the preepidemic period, admissions for GSW assaults averaged 10.24 per month or 123 per year. The 385 GSW admissions in fiscal 1990, therefore, represent 262 more than would have been expected if the epidemic of gun violence had not occurred. This increase in GSW admissions translates into an additional $3.9 million in hospital costs for fiscal 1990; however, the increased financial burden of treating patients with GSWs is likely to have been greater because the severity of wounds increased concomitantly with patient volume. Only half of the hospital's costs for treating patients with GSWs were reimbursed in fiscal 1990 because 37% of patients with GSWs were uninsured and 35% were covered by government programs that do not reimburse payments for the full cost of care.

Despite the unfortunate consequences for the victim, the increasing number and severity of GSWs treated at Washington Hospital Center has made for excellent training opportunities for surgeons, especially military surgeons who rotate through the trauma service. Although differences between GSWs of civilian and military patients have been documented,[9,10] the increasing incidence of multiple GSWs from military-style street weapons is closing this gap (*Am Med News*. April 14, 1989:3).

Despite differences in surgical treatment of many wounds of civilian and military patients, skills in basic assessment and resuscitation are largely transferrable.

Police data on homicide motives suggest that the violence associated with the trade of crack-cocaine played a key role in the onset of the city's epidemic of gun-related homicides and assaults. Drug-related homicides grew from 14% in 1986 to 53% in 1988, and accounted for 80% of the increase in homicides during that period.[5] Although the proportion of homicides considered to be drug-related declined in 1990, and other indexes suggest that the relative importance of drugs in violent crime has begun to diminish in Washington, DC, the legacy of sophisticated weaponry is very much in evidence.[11]

More and more assailants have switched from revolvers to high-capacity semiautomatic pistols. In 1987, revolvers outnumbered semiautomatic pistols by a ratio of 2:1 among the handguns seized by the DC Metropolitan Police Department. From 1987 to 1990, the number of semiautomatic pistols confiscated doubled, while the number of revolvers seized did not change. By 1991, semiautomatic pistols outnumbered revolvers 1011 to 799 among guns confiscated by the police (*The Washington Post*. February 2, 1992:A1). Earlier research indicated that the types of guns confiscated by police are likely to be representative of those used in all assaults and homicides.[12] Data collected by the Federal Bureau of Alcohol, Tobacco, and Firearms indicate that the shift toward semiautomatic pistols during the late 1980s was not unique to the nation's capital (*Atlanta Journal and Constitution*. May 21, 1989).

Although little research has been done in this area, the increased popularity of high-capacity semiautomatic pistols could have significant effect on public safety. High-capacity semiautomatic handguns enable assailants to fire more bullets at their victims more quickly than do revolvers, both increasing the likelihood of hitting one or more victims and increasing the number of wounds to any particular victim. Our data do not allow us to assess any increase in the likelihood of one or more victims being wounded in gun assaults. Trauma surgeons in Los Angeles (Calif) have noted an increase in multiple-victim incidents involving assault-style weapons (*Am Med News*. April 14, 1989:3). Although it is difficult to quantify such incidents, using existing medical or police data, we observed increases in the percentage of patients with two or more GSWs, the mean number of entrance wounds per patient, and the proportion of patients with five or more entrance wounds.

The available data preclude us from directly attributing changes in the number of wounds per patient to changes in gun type. Information about the type of weapon used in an attack usually is not available from medical records, and even if such information was available, correlations between the type of gun and the number of wounds may be confounded by the degree of the assailant's intent to kill. That is, assailants who are more deliberate in their attempts to kill their victims by shooting them multiple times (eg, drug enforcers) may be more likely to use high-capacity, rapid-fire guns. If that is the case, the observed increase in the number of wounds per patient may be partly attributable to a disproportionate increase in gun attacks that were very deliberate attempts to kill the victims.

Although there has most likely been some increase in the intent to kill during gun attacks due to the increasing prominence of drug-related violence, the observed increase in wounds per victim is likely to have been facilitated by the availability of semiautomatic guns with high-capacity ammunition clips. Uzis and Tech-9s, originally designed for military use, can hold more than 30 rounds and can fire up to eight rounds per second.

Epidemiologic studies that provide good estimates of the harm attributable to high-capacity semiautomatic weapons, while taking into account confounding effects related to assailant intentions, would be important contributions to the policy debate concerning the banning or regulation of the sale of this class of weapon. While well-controlled epidemiologic studies could provide more precise estimates of the degree to which high-capacity semiautomatic guns are more harmful than other handguns, the design of these guns may be so inherently dangerous to public safety that immediate legislative action is warranted. The American Medical Association and the American College of Surgeons have called for legislative efforts to restrict civilian access to high-capacity, high-rate-of-fire automatic or semiautomatic firearms.[13,14] The enactment and enforcement of such restrictions should reduce the number and the severity of firearm injuries.

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Exhibit T

Letters

RESEARCH LETTER

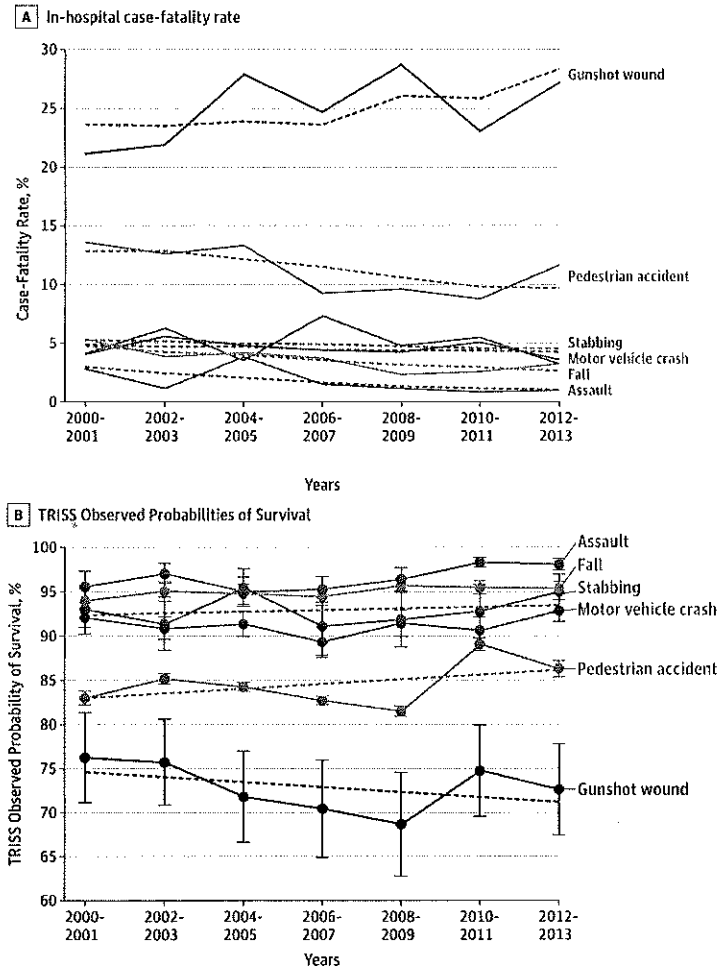
Fatality and Severity of Firearm Injuries in a Denver Trauma Center, 2000-2013

Death rates provide an incomplete picture of the effect of firearm injuries. To devise appropriate prevention efforts, investigations of the severity and prognosis of both fatal and nonfatal gunshot wounds (GSW) are pivotal, yet they remain scarce.[1-3] We studied temporal patterns of GSW-associated severity and mortality in a Colorado urban trauma center and of all trauma deaths occurring in its catchment area from 2000 to 2013.

Methods | We queried the state-mandated trauma registry of a level 1 trauma center (Denver Health Medical Center, DHMC) for data on injuries, cause, and severity for all patients who died in the hospital, were hospitalized, or required more than 12-hour observation from 2000 to 2013. Throughout this period, the DHMC catchment area was Denver County. To assess injury deaths at the scene (vs in-hospital), we obtained all Denver County records of trauma deaths during the same period. The Colorado Multiple Institutional Review Board approved the study with a waiver of consent.

Injury severity was quantified by the Injury Severity Score (ISS; range, 1-75), a score for multiple injuries.[4] Each single injury was assigned an Abbreviated Injury Scale (AIS; 1 = minor injury to 6 = lethal injury) score, with severe defined as a score higher than 2. The maximum AIS score from the 3 most severely injured body regions was squared

Figure 1. Case-Fatality Rates and Trauma and Injury Severity Score (TRISS) Observed Probabilities of Survival by Mechanism per Biennium

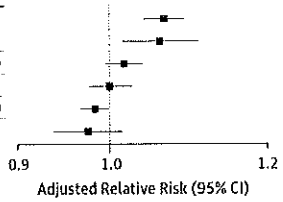


Error bars indicate 95% confidence intervals. Gunshot wound was the only mechanism with a significant increase in case-fatality rates and a significant decrease in TRISS-derived survival probabilities. A, Unadjusted rates are the solid lines and adjusted rates are the dashed lines. B, Dashed lines represent simple linear trends. Linear trends shown only for selected mechanisms.

Figure 2. Relative Risk per Biennium for an Injury Severity Score Higher Than 25 and for Having More Than 2 Severe Injuries (Abbreviated Injury Scale [AIS] Score >2) by Mechanism

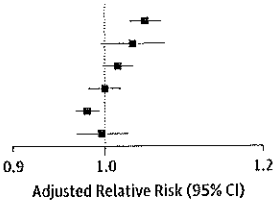
A Relative risk per biennium for Injury Severity Score >25

Mechanism of injury	Adjusted Relative Risk (95% CI)
Gunshot wound	1.07 (1.04-1.09)
Stabbing	1.06 (1.02-1.11)
Pedestrian accident	1.02 (0.997-1.04)
Fall	1.00 (0.98-1.03)
Motor vehicle crash	0.98 (0.97-0.998)
Assault	0.98 (0.94-1.01)



B Relative risk per biennium for having >2 severe injuries (AIS score >2)

Mechanism of injury	Adjusted Relative Risk (95% CI)
Gunshot wound	1.05 (1.03-1.07)
Stabbing	1.03 (0.996-1.07)
Pedestrian accident	1.02 (0.999-1.03)
Fall	1.00 (0.98-1.02)
Motor vehicle crash	0.98 (0.97-0.99)
Assault	0.998 (0.97-1.03)



For each mechanism of injury, the relative risk comparator is all other mechanisms of injury shown in the graphs. A, After adjustment for age and sex, the risk of having severe injuries over time significantly increased for gunshot wounds (6.5% per biennium) and stabbings (6.0% per biennium). B, After adjustment for age and sex, gunshot wounds was the only mechanism for which the risk of having more than 2 severe injuries (AIS score >2) significantly increased over time (4.8% per biennium).

and added to produce the ISS. Patients with ISS higher than 25 were considered severely injured.

Poisson regression models with robust standard errors were used to estimate relative risks (RR) and risk differences (RD) of in-hospital mortality, an ISS higher than 25, and having more than 2 severe injuries (AIS score >2), by mechanism and biennium (to produce more stable estimates), adjusting for age and sex. Temporal trends by injury mechanism were assessed by including an interaction between mechanism and biennium. Linear regression was used to model temporal trends of proportion of deaths at the scene and survival probabilities derived through the Trauma and Injury Severity Score (TRISS), a benchmarking tool widely used to estimate trauma survival probabilities based on age, mechanism, admission vital signs, and injury severity.[5]

There were less than 6% of missing values. SAS (SAS Institute), version 9.4, was used for all analyses. All tests were 2-tailed with significance set at less than .05. The institutional review board approved the study with a waiver of consent.

Results | From 2000 to 2013, 28 948 patients presented to the DHMC with injuries due to GSWs (5.8%), stabbings (6.3%), pedestrian accidents (6.9%), assaults (8.7%), falls (23.9%), motor vehicle crashes (26.2%), and other mechanisms (22.1%). Of these, 5.4% died. The proportions of DHMC injury admissions due to GSWs, stabbings, and assaults remained stable from 2000 to 2013, whereas falls increased (from 16.8% to 27.8%) and motor vehicle crashes decreased (from 37.0% to 19.7%) over time. Adjusted in-hospital case-fatality rates for GSWs at the DHMC significantly increased (RR per biennium, 1.06 [95% CI, 1.03-1.08]; RD, 0.51% [95% CI, 0.01%-1.02%]) (**Figure 1A**) and the TRISS-derived survival probabilities decreased ($P = .002$) (Figure 1B). All other mechanisms presented stable or opposite temporal trends for deaths and survival probability. Over time, more GSW patients had an ISS higher than 25 (RR per biennium, 1.06 [95% CI, 1.04-1.08]; RD, 1.16% [95% CI, 0.68%-1.65%]). In addition, the number of severe GSWs per patient increased significantly (RR per biennium of >2 severe injuries, 1.04 [95% CI, 1.02-1.06]; RD, 1.22% [95% CI, 0.66%-1.79%]) (**Figure 2**).

In Denver County during this same period, there were 4762 trauma deaths (falls, 28.4%; GSWs, 22.9%; motor vehicle crashes, 19.9%; pedestrian accidents, 4.0%; stabbings, 2.4%). Of these, 64.1% occurred in-hospital (50.9% at the DHMC) and 35.9% were pronounced outside a health care facility. Of the 1092 GSW deaths, 47.3% were in-hospital (81% at the DHMC), and this proportion did not vary significantly over time ($P = .62$). Only for falls was a decrease in the proportion of in-hospital deaths detected (from 81.0% to 41.6%, $P = .006$).

Discussion | Firearm in-hospital case-fatality rates increased, contrary to every other trauma mechanism, attributable to the rising severity and number of injuries. The differential in severity and mortality is unlikely due to improved emergency medical services (ie, more severely injured patients arriving alive to the hospital vs dying in the field), as there were no changes in deaths at the scene over time. This single trauma center study has limited generalizability. A renewed attention to research and policy are needed to decrease the morbidity and mortality of GSWs.[6]

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Author Contributions: Dr Sauaia had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Sauaia, Gonzalez, E. Moore.
Acquisition, analysis, or interpretation of data: All authors.
Drafting of the manuscript: Sauaia, E. Moore.
Critical revision of the manuscript for important intellectual content: All authors.
Statistical analysis: Sauaia, H. Moore, Bol.
Administrative, technical, or material support: Sauaia, Gonzalez, E. Moore.
Study supervision: Sauaia, E. Moore.

Conflict of Interest Disclosures: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest and none were reported.

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COMMENT & RESPONSE

Long QT Syndrome and Potentially Pathogenic Genetic Variants

To the Editor Dr Van Driest and colleagues[1] presented a negative study on novel criteria for secondary variants for long QT syndrome. They identified 127 candidate *SCN5A* or *KCNH2* variants and considered 63 potentially pathogenic, using unspecified review criteria in 3 clinical laboratories. This number reflects an overall rate of 3.1%, which, as they noted, is unexpectedly high and biologically implausible, because the upper estimate of long QT syndrome prevalence is 1 in 2500 (or minor allele frequency [MAF] of 0.02%). As expected, by using such liberal criteria, they found that these variants were not associated with an abnormal phenotype.

Previously, criteria for reporting secondary variants in these genes were developed that required a MAF no higher than that for the disease overall and either 3 independent reports of pathogenicity or 2 such reports and supporting evidence (typically functional data) with no conflicting benign data.[2] Applying more restrictive criteria to the 127 variants identified by Van Driest and colleagues would likely identify few as pathogenic. Van Driest and colleagues[1] overinterpreted their data in concluding, "These findings raise questions about the implications of notifying patients of incidental genetic findings." The most appropriate conclusion is that the thresholds of the 3 clinical laboratories involved are less stringent and have lower positive predictive values (PPVs) than current standards and that further filtering is required prior to reporting. Had these data been analyzed according to the American College of Medical Genetics and Genomics (ACMG) recommendations[3] and previously published recommendations for long QT syndrome,[2] no variants would have been reported, which is a superior outcome compared with that reached by Van Driest and colleagues.

It is inevitable and desirable that the ACMG incidental findings gene list[3] should evolve by the removal of genes that can be demonstrated to have poor PPV and the addition of genes that can be shown to have good PPV. If the findings of Van Driest and colleagues are generalizable and clinical laboratories cannot effectively identify secondary variants in these genes, change to a model of only reporting secondary variants from a robustly vetted list of unambiguously pathogenic alleles may be necessary. The paradigm of sacrificing sensitivity for PPV was part of the original ACMG recommendations, and it may be worth pursuing that approach further for genes that are difficult for clinical laboratories to interpret. *KCNH2* and *SCN5A* may be examples where this approach has merit, although more data would be needed before adoption.

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Conflict of Interest Disclosures: The author has completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest and reported receiving a grant from the National Institutes of Health Intramural Research Program, editing honorarium from Wiley-Blackwell, and royalties from Genentech and serving as an uncompensated consultant to Illumina Corp.

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In Reply When health care clinicians are notified of an incidental "pathogenic" variant, they must determine the best course of action with respect to return of the result to the patient, further workup, and any therapeutic measures. In our study, to most closely simulate "real-world" results, variants identified in *SCN5A* and *KCNH2* were classified as pathogenic or nonpathogenic by expert laboratories, the same laboratories that generate clinical reports and provide variant calls to databases like the Human Gene Mutation Database and ClinVar. As noted by Dr Biesecker, this approach resulted in a much higher frequency of pathogenic variants than the associated diseases, long QT syndrome and Brugada syndrome. Not surprisingly, owing to the low prevalence of these syndromes, review of the electronic health records of the research participants with these variants showed that they had not manifested disease.

Our data, together with others,[1-4] are a call for action, concern, and reassurance. As Biesecker suggests, variant classification thresholds require recalibration and harmonization, in particular when transitioning from evaluation of variants found in symptomatic individuals to incidental findings, for which the pretest probability of disease is very low. Guidelines from the ACMG, published after variant classification was complete for our study, include criteria that echo the MAF and prior evidence thresholds proposed by Biesecker.[4,5] It will take considerable continued energy to adapt and interpret these guidelines for specific genes and diseases such as long QT syndrome and even more to align diagnostic and research laboratories around a common variant classification rubric. We propose that electronic health record cohorts may be 1 source of valuable data to define the PPV of these rubrics, a goal of the studies in phase 3 of the Electronic Medical Records and Genomics project.

Exhibit U

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AMERICA'S OLDEST CONTINUOUSLY PUBLISHED NEWSPAPER

Hartford Courant

VOLUME CLXXVI NUMBER 358 COURANT.COM • MOBILE.COURANT.COM SUNDAY, DECEMBER 23, 2012

STARTING OVER

NEW SCHOOL, MADE FAMILIAR

Hundreds Of Volunteers Help Ease Transition For Sandy Hook Kids

By BRIAN DOWLING
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Sandy Hook Elementary School students will find that volunteers have painted the walls of their new school green and white, their school colors. The movers set furniture, desks, computers and supplies in the same places as their old classrooms in Newtown. Volunteers pinned the same posters to new classroom walls.

The re-creation of Sandy Hook Elementary at Chalk Hill School in Monroe involved hundreds of people over the past week. Locksmiths, plumbers, electricians, custodians, experts in fire suppression and security systems, as well as residents with paint brushes, all volunteered time to create an around-the-clock renovation team, which peaked at 500 workers.

Thanks to that effort, the surroundings will be

CHALK HILL, A4

WFSB | POOL

THE WELCOME sign is ready at Chalk Hill School in Monroe, where Sandy Hook students will begin classes Jan. 3.

ADAM LANZA

Shooter Paused, And Six Escaped

By DAVE ALTIMARI, EDMUND H. MAHONY and JON LENDER
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As many as a half-dozen first-graders may have survived Adam Lanza's deadly shooting spree at Sandy Hook Elementary School because he stopped firing briefly, perhaps to reload his rifle or because it jammed, according to law enforcement officials familiar with the events.

A source said that the Bushmaster rifle that Lanza used in the shootings is at the state police forensic laboratory undergoing several tests, including tests to determine whether it jammed.

The children escaped from the first-grade classroom of teacher Victoria Soto, one of the six educators Lanza killed in Newtown after shooting his way through a glass door with the .223-caliber semiautomatic rifle on the morning of Dec. 14.

On Friday, detectives obtained and began examining records related to psychiatric care Lanza had received

RIFLE, A6

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TRAGEDY IN NEWTOWN

Rifle

Continued from Page A1

in an attempt to determine a motive. Several friends of his mother have said that he had Asperger's syndrome but authorities have neither confirmed that nor indicated it had anything to do with the shootings.

Lanza killed 27 people — 20 children, four teachers, the school principal, a school psychologist and his mother, Nancy — before shooting himself in the head as police began arriving at the school.

The arriving officers encountered a shocking scene in Soto's classroom. Lanza had shot her, as well as special education teacher Anne Marie Murphy and six of Soto's 6- and 7-year old students. Seven of Soto's students were found huddled and unharmed in a classroom closet, apparently hidden by Soto when she heard shooting. The other students fled the classroom.

Based on initial statements from surviving children and the fact that unfired cartridges from Lanza's rifle were found on the ground, detectives suspect that some students were able to run to safety when Lanza stopped firing, probably for a short period of time, the officials said.

It is possible that Lanza, who reloaded the rifle frequently, mishandled or dropped a magazine and cartridges fell to the floor, they said.

But it also is possible, they said, that the mechanism that fed cartridges into the rifle jammed, causing Lanza to remove the magazine and clear the weapon. Unfired cartridges could have fallen to the classroom floor during that process as well, law enforcement officials said.

The six children who escaped Lanza's rampage ran to a home a short distance from the school. Upon reaching the home, one of the boys told the owner that "we obeyed the rules, we stayed on the sidewalk," one of the officials said.

The authorities have learned generally from the children who ran away that something may have happened to Lanza's rifle that caused him to stop firing. The substance of the statements, which are not entirely consistent, is that a piece of the weapon, probably a magazine holding live cartridges, was dropped or fell to the classroom floor.

Investigators have decided not to formally interview the children, based on advice from Yale child psychologists. Given the chaotic nature of the scene, it is also possible that some children escaped while Lanza was shooting others.

State police are expected to wrap up work at the school and release the school as a crime scene in the next few days. They still are trying to determine how many shots Lanza fired.

Lanza killed himself in Soto's classroom with one of the two pistols he carried into the building. He killed himself as police entered the building.

Police found a loaded 20-round shotgun in the trunk of the car similar to what is known as a "street sweeper." Police believe that Lanza didn't bring it into the school because he couldn't carry all of the weapons and ammunition. Lanza, who was about 6 feet tall, weighed barely 110 pounds, law enforcement sources said.

The few people who knew Lanza have portrayed him in the days since the mass shootings as an awkward, emotionally isolated, withdrawn young man. He attended public schools in Newtown, but at times was home-schooled by his mother, who was said by authorities and others to be the only person with whom he was socially engaged.

Lanza lived with his mother. He had two bedrooms and used one of them to keep computer equipment on which he is said to have enjoyed playing video games involving violent war games.

Before the shootings at the elementary school, Lanza shot his mother four times with a .22-caliber rifle as she lay in bed. He left that rifle at the house. All the guns were properly registered to Nancy Lanza.

Adam Lanza also broke apart his computer equipment in a way that has prevented authorities from retrieving data that could reveal with whom he may have corresponded or played video games.

He then drove to the school, getting there about 9:30 a.m. He walked up to the front entrance and fired at least a half-dozen rounds into the glass doors. The thunderous sound of Lanza blowing an opening big enough to walk through the locked school door caused Principal Dawn Hochsprung and school psychologist Mary Scherlach to bolt from a nearby meeting room to investigate.

He shot and killed them both as they ran toward him. Two other staff workers in a meeting with Hochsprung and Scherlach were injured in the hail of bullets but made it back inside the conference room where one called 911 from under a table.

Lanza then turned toward the first classroom on his left, that of teacher Kaitlin Roig. By then, authorities said, Roig had hidden with her students in a closet in her classroom. Before securing the closet door, which opened inward, authorities said she concealed the door behind a movable bookcase.

Lanza then walked past Soto's classroom into the third one, where Lauren Rousseau was teaching. He shot and killed Rousseau, special education teacher Rachel D'Avino and 14 students.

One member of the class was not killed, although it is not clear if the child escaped the shooting or was not in the room.

"I think the community is very much respecting their privacy," Newtown schools Superintendent Janet Robinson said of the student's family. "I think that everyone is very sensitive to what a horrific experience this 6-year-old ... has been through."

Much later, after police had found Lanza's body and were searching for survivors, an officer had to slide a badge beneath the closet door before Roig could be persuaded to open it.

Courant staff writer Matthew Sturdevant contributed to this story.